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STUDIES OF CHILDHOOD.

II.—THE IMAGINATIVE SIDE OF PLAY.

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CHILDREN'S play has been studied under different aspects. One of the most attractive of these is its imaginativeness. All play is to some extent fanciful—that is, inspired and vitalized by fantasy; and the element of fancifulness is especially rich and varied in the pastimes of the small people of the nursery.

Viewed on this side, child play may be described as the working out into actual visible shape of an inner fancy. In many cases, no doubt, the actual surroundings may supply the starting point; the child, for example, sees the sand, the shingle, and shells, and says, Let us play keeping a shop. Yet this suggestion by something present is accidental. The root impulse of play is to realize a bright, pretty idea; hence its close kinship with art as a whole. This image is the dominating force; it is for the time a veritable *idée fixe*, and everything has to accommodate itself to this. Since the image has to be acted out, it comes into collision with the actual surroundings. Here is the child's opportunity. The carpet is instantly mapped out into two hostile territories; the sofa-head becomes a horse, a coach, a ship, or what not, to suit the exigency of the play.

This stronger movement and wider range of childish imagination in play is explained by the characteristics and fundamental impulse of play—the desire to be something, to act a part. The child adventurer, as he personates Robinson Crusoe or other hero, steps out of his every-day self and so out of his every-day world.

In realizing his part he virtually transforms his surroundings, since they take on the look and the meaning which the part assigns to them. This is prettily illustrated in one of Mr. R. L. Stevenson's child-songs, The Land of Counterpane, in which a sick child describes the various transformations of the bed scene:

"And sometimes for an hour or so
I watched my leaden soldiers go,
With different uniforms and drills,
Among the bedclothes through the hills.

"And sometimes sent my ships in fleets,
All up and down among the sheets;
Or brought my trees and houses out,
And planted cities all about."

Who can say to how many and what strangely play purposes that stolid, unyielding-looking object a sofa-head has been turned by the ingenuity of the childish brain?

The impulse to act a part meets us very early and grows out of the imitative instinct. The very infant, if it finds an empty cup to hand, will proceed to drink out of it.* Similarly, a boy of two will put the stem of his father's pipe into or, if more cautious, near his mouth, and make believe that he is smoking. A little boy not yet two years old would spend a whole wet afternoon "painting" the furniture with a dry end of a bit of rope. In such cases it is evident the playing may start from a suggestion supplied by the sight of an object. There is no need to suppose that in this simple imitative play the children consciously act a part. It is surely to misunderstand the essence of play to speak of it as a fully conscious process of imitative acting.† A child is one creature when it is truly at play, another when it is bent on astonishing or amusing you. It seems sufficient to say that when at play it is possessed of an idea and is working this out into visible action. Your notice, even your laughter, if kind enough, may bring in a new element of enjoyment, for, as we all know, children are disposed to be little actors in the full sense, and to aim at producing an impression. Yet your intrusion will be at least just as likely to destroy the pleasure in so far as it is that of pure childish pastime; for the play instinct comes out most distinctly, perhaps, when a child is alone, or at least self-absorbed, and this suggests that the instinct springs out of the deepest and least sophisticated part of its nature.

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* Of course, as Preyer suggests, this drinking from an empty cup may at first be due to a want of discriminative perception.

† M. Compayré seems to go too far in this direction when he talks of the child's play with its doll as a charming comedy of maternity. (L'Evolution intellectuelle et morale de l'Enfant, p. 274.)

The essence of play is the realizing of an imaginary situation or action; it is thus in a sense dramatic; only that the child's drama, like M. Jourdain's prose, is unconscious. In this impulse to be something, the actual external surroundings play a greater or less part according to the needs of the player. Sometimes there is scarcely any adjustment of the actual objects and scene; the child plays out its action with purely imaginary surroundings, including companions or playmates. Thus one mother writes of her boy, aged two years and a half: "He amuses himself by pretending things. He will fetch an imaginary cake from a corner, rake together imaginary grass, or fight a battle with imaginary soldiers." As a recent little work shows,* some children have adopted permanently an invisible playmate. In such vivid realization the utmost interference with actual surroundings that is needed is change of place. Here is a pretty example of this simple imaginative play. A child of twenty months, who was accustomed to meet a *bonne* and child in the Jardin du Luxembourg, suddenly leaves the family living room, pronouncing indifferently well the names "Luxembourg," "bonne," and "enfant." He goes into the next room, pretends to say "good day" to his two outdoor acquaintances, and then returns and narrates what he has been doing.† Here the simple act of passing into an adjoining room was enough to secure the needed realization of the encounter in the garden. The movement into the next room is suggestive. Primarily it meant, no doubt, that it was the child's way of realizing the out-of-door walk; yet I suspect that there was another motive at work. Children love to enact their little play-scenes in some remote spot, withdrawn from notice, where imagination suffers no let from the intrusion of mother, nurse, or other member of the real environment. How many a thrilling, exciting play has been carried out in a corner, especially if it be dark, or, better still, screened off! The fascination of curtained spaces, as those behind the window curtains, under the table with the tablecloth hanging low, will be fresh in the memory of all who can recall their childhood.

A step toward a more realistic kind of play-action, in which, as in the modern theater, imagination is propped up by strong scenic effects, is taken when a scene is constructed, the chairs and sofa turned into ships, carriages, a railway train, and so forth.

Yet, after all, the scene is but a very subordinate part of this infantile play. Next to itself proudly enjoying the part of the rider, the soldier, the engine-driver, or what not, the child wants

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* The Invisible Playmate, by Canton. London, Isbister; pp. 33 and following.

† Egger, quoted by Compayré, L'Evolution intellectuelle et morale de l'Enfant, pp. 149, 150.

a living companion. Something alive there must be, or at least something to simulate life, if only a railway engine. And here we meet with what is perhaps the most interesting feature of childish play—the transmutation of the most meager and least promising things into complete living forms. I have already alluded to the sofa. How many forms of animal life, vigorous and untiring, from the patient donkey up to the untamed horse of the prairies, has this most inert-looking ridge served to image forth to quick boyish perception!

The introduction of these living things seems to illustrate the large compass of the child's realizing power. Mr. Ruskin speaks somewhere of "the perfection of childlike imagination, the power of making everything out of nothing. . . . The child," he adds, "does not make a pet of a mechanical mouse that runs about the floor. . . . The child falls in love with a quiet thing, with an ugly one—nay, it may be with one to us totally devoid of meaning. The *besoin de croire* precedes the *besoin d'aimer*."

The quotation brings us to the focus where the rays of childish imagination seem to converge, the transformation of toys.

The fact that children make living things out of their toy horses, dogs, and the rest is known to every observer of their ways. To the natural, unskeptical eye the boy on his rude-carved wooden "gee-gee," slashing the dull flanks with all a boy's glee, is realizing the joy of actual riding; is possessed for the moment with the glorious ideas that the stiff, least organic-looking of structures which he strides is a very horse.

The liveliness of this realizing imagination is seen in the extraordinary poverty and meagerness of the toys which to their happy possessors are wholly satisfying. Here is a pretty picture of child's play from a German writer:

"There sits a little charming master of three years before his small table, busied for a whole hour in a fanciful game with shells. He has three so-called snake-heads in his domain—a large one and two smaller ones; this means two calves and a cow. In a tiny tin dish the little farmer has put all kinds of petals—that is, the fodder for his numerous and fine cattle. When the play has lasted a time the fodder dish transforms itself into a heavy wagon with hay; the little shells now become little horses, and are put to the shaft to pull the terrible load." *

The doll takes a supreme place in this fancy-realm of play. It is human, and satisfies higher instincts and emotions. As a French poet says, the little girl

"Rêve le nom de mère en berçant sa poupée."

* Goltz, Buch der Kindheit, pp. 4, 5.

But the boy has his doll-love also, and is often hardly less faithful than the girl. Endless is the variety of *rôle* assigned to the doll as to the tiny shell in our just-quoted description of play. The doll is the all-important comrade in that *solitude à deux* of which the child, like the adult, is so fond. Mrs. Burnett, in her pleasant memoir of her childhood,* tells us that while sitting and holding her doll in the armchair of the parlor she would sail across enchanted seas to enchanted islands, meeting with all sorts of thrilling adventures. At another time, when she wanted to act an Indian chief, the doll just as obediently took up the part of squaw.

Very humanly, on the whole, is the little doll-lover wont to use her pet, even though, as George Sand reminds us, there come moments of rage and battering. A little boy of two and a half years asked his mother one day, "Will you give me all my picture books to show dolly? I don't know which he will like best." He then pointed to each in turn, and looked at the doll's face for the answer. He made believe that it selected one, and then gravely showed it all the pictures, saying, "Look here, dolly," and carefully explaining them. In this way does the child seek to bring his mute playmate into the closest intimacy with himself, sharing his life to the full. The same thing is touchingly illustrated in the fact that Laura Bridgman, when visited by Dickens in 1842, was found to have put a tiny band over her doll's eyes to match the band she herself had to wear. It is illustrated further in the fact that a child is apt to insist on dolly's being treated by others as courteously as himself, expecting them to say good night to it on saying good night to himself, and so forth.

Here, nobody can surely doubt, we have the clearest evidence of play illusion. The lively imagination endows the inert wooden thing with the warmth of life and love. How large a part is played here by the alchemist, fancy, is known to all observers of children's ways. The faith, the devotion, often seem to increase as the first meretricious charms, the warm tints of the cheek and the lips, the well-shaped nose, the dainty clothes, prematurely fade, and the lovely toy which once kept groups of hungry-looking children gazing long at the shop window is reduced to the naked essence of a doll. A child's constancy to its doll when thus stripped of exterior charms and degraded to the lowest social stratum of dolldom is one of the sweetest and most humorous things in child life.

And then, what rude, unpromising things are adopted as doll pets! Mrs. Burnett tells us she once saw a dirty mite sitting on

* The One I knew the Best of All.

a step in a squalid London street, blissfully engaged in cuddling warmly a little bundle of hay tied round the middle by a string. Laura Bridgman made a "baby" of a man's large boot. In these cases, surely, the *besoin d'aimer* was little if any behind the *besoin de croire.*

Do any of us really understand this doll superstition? Writers with clear, long-reaching memory have tried to take us back to childhood, and restore to us for a moment the whole undisturbed trust, the perfect satisfaction of love which the child brings to its doll. Yet even the imaginative genius of a George Sand is hardly equal, perhaps, to the feat of resuscitating the buried companion of our early days and making it live once more before our eyes. The truth is, the doll illusion is one of the first to pass. There are, I believe, a few sentimental girls who make a point, when they attain the years of enlightenment, of saving their dolls from the general wreckage of toys. Yet I suspect that the pets, when thus retained, are valued more for the outside charm of pretty face and hair, and most of all of their lovely clothes, than for the inherent worth of the doll itself—of what we may call the doll soul, which informs it and gives it to the child its true beauty.

Yet, if we can not get inside the old doll superstition, we may study it from the outside, and draw a helpful comparison between it and other known forms of sweet credulity. And here we have the curious fact that the doll exists not only for the child but for the "Nature-man." Savages, Sir John Lubbock tells us,* like toys such as dolls, Noah's arks, etc. The same writer remarks that the doll is "a hybrid between the baby and the fetich, and that it exhibits the contradictory character of its parents." Perhaps the changes of mood toward the doll of which George Sand writes illustrate the alternating preponderance of the baby and the fetich aspect. But, as Sir John also remarks, this hybrid is singularly unintelligible to grown-up people, and it seems the part of modesty here to bow to one of Nature's mysteries.

The vivification of the doll is the outcome of the play impulse, and this, as we have seen, is an impulse to act out, to realize an idea in outward show. The absorption in the idea and its outward expression serves to blot out the incongruities of scene and actors which you or I, a cold observer, would note.

How complete this play illusion may become here can be seen in more ways than one. We perceive it in the child's jealous insistence that everything shall for the time pass over from the everyday world into the new fancy-created one. About the age of four, writes M. Egger of his boy, "Felix is playing at being coachman. Emile happens to return home at the moment. In

* Origin of Civilization. Appendix, p. 521.

announcing his brother, Felix does not say, 'Emile is come'; he says, 'The brother of the coachman is come.'" * Pestalozzi's little boy, aged three years and a half, was one day playing at being butcher, when his mother called him by his usual diminutive, "Jacobli." He at once replied: "No, no; you should call me butcher now." †

The intensity of the imaginative realizing powers in play is seen, too, in the stickling for fidelity to the original in all playful reproduction, whether of scenes observed in everyday life or of what has been narrated. The same little boy who showed his picture books to dolly was, we are told, when two years and eight months old, fond of imagining that he was Priest, his grandmamma's coachman. "He drives his toy horse from the armchair as a carriage, getting down every minute to 'let the ladies out' or to 'go shopping.' The make-believe extends to his insisting on the reins being held while he gets down, and so forth." The same thing shows itself in acting out stories. The full enjoyment of the realization depends on the faithful reproduction, the suitable outward embodiment of the vivid detailed idea in the player's mind. A delightful example of boyish exactitude in acting out a story may be found in Mark Twain's picture of Tom Sawyer and Huckleberry Finn playing at being shipwrecked on a desert island.

The following anecdote bears another kind of testimony—a most winsome kind—to the reality of children's play: One day two sisters said to one another, "Let us play being sisters." This might well sound insane enough to hasty ears, but is it not really eloquent? To me it suggests that the girls felt they were not realizing their sisterhood, not enjoying all the possible sweets of it, as they wanted to do; perhaps there had been a quarrel and a supervening childish coolness, and they felt that the way to get this vivid sense of what they were or ought to be one to the another was by playing the part, enacting a scene in which they would come close to one another in intense conjoint activity.

But there is still another and some will think a more conclusive way of satisfying ourselves of the reality of the play illusion. The child finds himself confronted by the unbelieving adult, who may even be cruel enough to laugh at his play and his day dreamings; and this frosty aloofness, this unfeeling quizzing of their little doings, is apt to cut the sensitive little nerves to the quick. I have heard of children who will cry if a stranger suddenly enters the nursery when they are hard at play and shows himself unsympathetic and critical. But here is a story which

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* Quoted by Compayré, *op. cit.*, p. 150.

† De Guimps's Life of Pestalozzi (English translation), p. 41.

seems to me even more conclusive on the point: "I remember" (writes a lady) "that one of my children, when about four, was playing 'shops' with the baby. The elder one was shopman at the time when I came into the room and kissed her. She broke out into piteous sobs; I could not understand why. At last she sobbed out, 'Mother, you *never* kiss the man in the shop.' For the time being her game was spoiled." The mother's kiss, though sweet in itself, had here wrought a sudden disillusion.

It is only right to say that this same lady adds that her children varied considerably in this susceptibility to the play illusion, and that she feels sure her second child, who is less intelligent, would not have troubled about the kiss.

Play may produce not only the vivid imaginative realization at the time, but a sort of mild permanent illusion. Sometimes it is a toy horse, in one case communicated to me it was a funny-looking toy lion, more frequently it is the human effigy, the doll, which, as the result of successive acts of imaginative vivification, gets taken up into the relation of permanent companion and pet. Clusters of happy association envelop it, endowing it with a fixed vitality and character. A mother once asked her boy of two years and a half if his doll was a boy or a girl. He said at first, "A boy," but presently correcting himself added, "I think it is a baby." Here we have a challenging of the inner conviction by a question, a moment of reflection, and as a result of this, the unambiguous confession that the doll had its place in the living human family.

Here is a more stubborn exhibition on the part of another boy of this lasting faith in the plaything called out by others' skeptical attitude. "When" (writes a lady correspondent) "he was just over two years old, L—— began to speak of a favorite wooden horse (Dobbin) as if it was a real living creature. 'No tarpenter (carpenter) made Dobbin,' he would say; 'he is not wooden, but kin (skin) and bones, and Dod (God) made him.' If any one said 'it' in speaking of the horse his wrath was instantly aroused, and he would shout indignantly: 'It! You muttent tay *it*, you mut tay *he*.' He imagined the horse was possessed of every virtue, and it was strange to see what an influence this creature of his own imagination exercised over him. If there was anything L—— particularly wished not to do, his mother had only to say, 'Dobbin would like you to do this,' and it was done without a murmur."

There is another domain of childish activity closely bordering on that play where we may observe a like suffusion of the world of sense by imagination. I refer to pictures and artistic representations generally. If in the case of adults there is a half illusion, a kind of oneiratic trance condition, induced by a picture or

dramatic spectacle, in the case of the less instructed child the illusion is apt to become more complete. I have several striking stories about the effect of pictures on children's minds. A picture seems very much of a toy to a child. A baby of eight or nine months will talk to a picture as to a living thing; and something of this tendency to make a fetich of a drawing survives much later.

A quaint anecdote is recorded in a collection of children's thoughts recently published in America.* One day F——, a boy of four, called on a friend, Mrs. C——, when she had just received a picture, a scene in winter, in which persons were represented as going to church, some on foot and others in sleighs. . . . F—— wanted to know where they were going, and Mrs. C—— told him. The next day he came and noticed the picture, and looked at Mrs. C—— and then at the picture, and said, "Why, Mrs. C——, them people haven't got there yet, have they?" What, it may be asked, did the boy mean by his question? Did he in his vivid imaginative realization actually confuse the representation with the reality represented, after the manner of the sailors who, visiting a theater where the actors were representing a struggle of smugglers with a captain, took the performance to be a reality and rushed on the stage in order to protect the captain? There seems to be less excuse for confounding representation and reality in the case of the picture than in that of the stage. Perhaps, however, the boy F—— was less stupid than is here suggested. Did he, as the result of an intense realization of the scene pictured, excogitate the idea that the picture must at least represent something actual—that is to say, going on at the moment? Here is an opportunity for the mind quick to disentangle childish thought.

However this be, the vivid realization of pictures by children is a well-certified fact. Here is a story of a little boy, aged three years and some months: "His mother had gone to the sea and L—— (the child) was staying at his grandfather's. One day he was looking at a picture of a stormy sea, and on the sea was a little boat with an old man and a girl in it. He had heard the story of Grace Darling and her father, and at once decided that the picture represented them. After talking about them for some time his thoughts turned to his mother, and he began to imagine all sorts of things about her: 'And mamma is on de tea (sea) in a ickle (little) boat, and de waves are dashing over it, and (with great excitement) it will be turned over and mamma ill be drowned, and de master (one of the names for himself) will not be dere to tave (save) her!' By this time the big tears were rolling down

* The Study of Children at the State Normal School at Worcester, Mass.

his cheeks, and he was in such an agony of grief that his grandmother had to take the picture from him and try to divert his thoughts."

Here, it is pretty evident, we have to do with a degree of illusion which equals if it does not surpass that of the most absorbing play. We must remember that a detailed pictorial representation, especially if it is colored, gives to the eye a full presentment of a scene and so favors a particularly clear and vivid imaginative realization. It is probable, too, that the abstract mode of representation in pictorial art, as compared, say, with that of the stage, hardly counts for the child's perception. Even the ordinary adult, innocent of artistic aims and methods, is wont, when gazing upon a painting, to lose all count of the picture as such, his consciousness being focused for the intense imaginative realization of its meaning.

I do not, of course, mean that all realization of form by the young mind is of this illusory intensity. One striking characteristic of children's fancy is to interpret rapidly the boldest hints of a representation of a familiar form, more especially that of man and of animals. All observers of imaginative children can testify as to the quickness with which they detect the semblance of a human or animal form in the irregular lines of a cracked ceiling, in the veining of marble, or in the lineal design of a carpet, not to speak of slight and imperfect pictorial sketches. They are apt, as already remarked, to show this imaginative facility with respect to the forms of letters. Here is an example: The pen of a little boy, well on in his fourth year, when tracing a letter L, happened to slip, so that the horizontal limb formed an angle upward, thus: L. He instantly saw the resemblance to the bent knee of the human form, and said, "Oh, he's sitting down." Similarly, when he made an F turn the wrong way, and then put the correct form to the left, thus, F H, he exclaimed, "They're talking together." Here, it is to be presumed, illusion is less complete, fancy amusing itself, so to speak, with the form and making it suggestive and representative. And probably the same applies to some of the earliest and clumsiest of children's attempts to draw men and horses, and so forth; only that here we have to do with a pre-existing idea and an artistic intention to give outer embodiment to this idea—a circumstance which tends to make the process of imaginative realization steadier and more dominant.

I have here dealt with children's play and kindred forms of activity as the outcome of a strong bent to imaginative realization, to the vivid, half-illusory picturing out of things. At the same time it is to be noticed that, in the forms in which this imaginative impulse works itself out, we see a good deal more of the

child's mind; we see intelligence and, to some extent, also character. Thus, before there can be the faithful mimetic play of our little coachman, there must have been close observation and memory of what was observed. On the other hand, that most useful quality of intelligence which we call resource and invention comes out clearly in all the freer and more original sorts of play. Again, while all children are players—did not Victor Hugo rightly make the little body-starved and mind-starved Fantine conserve the play instinct?—they exhibit many and even profound differences of mind and character in their play. How unlike the girl's passive, dreamy play—as when sitting and holding her doll—to the more active boy's play, with its vigorous fightings, its arm-aching draggings of furniture! How different, again, the inchoate idealess play of a stupid child with the contents of a Noah's ark from the well-considered, finished, and varied play of a bright, intelligent child with the same material! Curious differences of taste, too, and even of moral instinct reflect themselves in the play of children. There is a quaint precocity of the practical instinct, the impulse to make one's self useful, in some children, which is apt to come out in their play. The little boy referred to above, who would spend a whole wet afternoon "painting" the furniture, must have had a decided bent toward useful work. Other children are no less quaintly precocious in the matter of morals, laying down commands on their dolls, punishing them for being naughty, and so forth—all with the appearance of a real and earnest conscientiousness.

While the forms of imaginative activity in play are thus selectively determined by individual aptitudes and dispositions, they will, of course, throughout remain dependent on the special experiences and fields of observation. Play is largely imitative of what has been experienced by the child, seen by him, or told him by others. The richer the surroundings, the fuller the sources of instruction, the more elaborate and various can the play representation become. Boys' play is often an imitation of the doings of their fathers and others—that is to say, when, as in the case of the farmer, the engineer, or the soldier, the paternal vocation lends itself to an interesting kind of play action. The sons of literary men do not, so far as I have heard, render their sires this flattering attention. Possibly, now that women's occupations also are getting differentiated, girls will be found to follow in their play the special lines of activity of their respective mothers.

Enough has probably been said to show how interesting a subject for study is offered us in children's play. Here, as has been well said, we seem to catch the child in his own world, acting out his own impulses without stimulus, guidance, or restraint from

others. Here, with something of the poet, the artist, of the serious man of business, too, yet being in truth none of these, he sets about creating his own world—a world which, like those we all create in our several fashions, bears on every feature the stamp of the creative mind.

THE HUMMING BIRDS OF CHOCORUA.

By FRANK BOLLES.

WHILE snow still sparkles in the frost furrows on Chocorua's peak, the first rubythroats appear in the warm meadows and forest glades at the south of the mountain. They love the flowers as others of their race love them, and when apple blossoms bless the air with perfume and visions of lovely color and form, the humming birds revel in the orchards of the North as their brothers delight in the rich flowers of the tropics. It is not, however, among flowers that the Chocorua rubythroats are happiest or most frequently seen. Were some one to ask me to find a humming bird quickly, it would make no difference what the age of the summer or what the hour of the day, I should turn my steps toward the forest, feeling certain that at the drinking fountains of the yellow-breasted woodpecker, the red-capped tapster, and loud-voiced toper of the birch wood, I should find the rubythroats sipping their favorite drink.

About the middle of April, and again nearly six months later, a mischievous and wary woodpecker migrates north and south across New England. The casual observer might take him to be a demure little downy, intent upon keeping the orchard free from insects, and if the sly migrant was ordinarily quick in placing a tree trunk between his black-and-white body and the observer his identity would not be detected. On April 17, 1892, I noticed one of these birds clinging to a smooth spot on the trunk of a shagbark which grew on a warm pasture hillside in sight of Bunker Hill and the golden dome of the Massachusetts State House. Watching him carefully for a moment, I saw that he was a yellow-breasted or sap-sucking woodpecker, perhaps one of my own Chocorua neighbors, and that he was quietly sipping the sweet sap of the shagbark which was flowing from several small holes in the bark, drilled, no doubt, that very morning by the traveler so serenely occupied. The sapsuckers reach northern New Hampshire before the snow has wholly melted in the woods. I have seen them at Chocorua, on May 1st, at work upon trees which they had evidently been tapping for fully a week. From this time until the last of September, perhaps even till the 7th or 8th of October, they spend the greater part of their time drilling small

holes in the bark of their favorite trees and in sipping from the sap fountains thus opened the life blood of the doomed trees. They do not range about through the forest tapping one tree here and another there, but they select one, two, perhaps three groups of trees well lighted and warmed by the sun, and make sap orchards of them, clinging to them many hours at a time, week after week, and returning to them, or others close at hand, year after year. Within a mile of my cottage at the foot of Chocorua there are half a dozen of these drinking places of the yellow-breasted woodpeckers, and each one of them is a focus for rubythroats. The one which I have known longest I discovered in 1887. It consists of a group of gray birches, springing from a single stump and expanding into fifteen distinct trunks. When I first saw it all the trees were living, and nearly all of them were yielding sap from the girdles of small drills which the woodpeckers had made in the trunks, about nine feet from the ground. In July, 1893, all but three of the trees were dead, and of the dead trunks all except two had been broken off by the wind at a point a few inches below the drills. The surviving trees had been tapped, and were in use by both sapsuckers and humming birds. During 1890, 1891, and 1892 the humming bird in attendance at this orchard was a male of noticeably strong character. There was no mistaking him for any chance visitor at the place. He spent all his time there, and repelled intruders with great vigor, flying violently at them, squeaking, humming as noisily as a swarm of bees, and returning to his favorite perch as soon as they had been put to flight. He often attacked the sapsuckers themselves, buzzed in their faces, and seemed little abashed when they turned upon him, as they sometimes did, and drove him from their midst. He also had a habit of squeaking spitefully when he was drinking from the sap wells, especially on his return from a bout with some other humming bird. Searching for him in July, 1893, I failed to find him, but discovered that in his place a pair of birds seemed to have established themselves. Of course, it is possible that my friend of previous years may have taken to himself a wife and have become mild-mannered in consequence, but I find it impossible to believe in this theory, so pronounced were the old male's temper and peculiar ways. The new male, for example, did not use the same twigs for perches, and he did not keep his head wagging from side to side as the old one did with a vigor and regularity which nothing but a pendulum ever equaled.

The new male, however, showed me a performance far more interesting in character than any of his petulant predecessor's, and one which establishes the Chocorua rubythroat as a musician and a dancer. One day, while this male was drinking at the sap fountains, a female arrived. The male greeted her with squeaks and

intense humming. She alighted on the tree near the drills, and the male then hurled himself through the air with amazing speed, describing a curve such as would be drawn by a violently swung pendulum attached to a cord fifteen or eighteen feet long. The female was at the lowest point of the arc described by her vehement admirer, and she sat perfectly motionless while he swung past her eight times. When he moved fastest—that is, when he approached and passed her—he produced in some unknown way a high, clear, sweet musical note, louder even than the humming which was incessant during his flight. In this first performance the male moved from north to south. A few minutes later he went through the dance a second time, describing a shorter curve and moving east and west. Still a third time, when the female had taken position in the midst of a few dense branches, the male faced her, and in a short arc, the plane of which was horizontal, flew back and forth before her. I had seen this performance once before, in July, 1890, at another orchard, and at that time I fancied that both birds took part in the flight, but in this case the birds were close above me as I lay among the ferns, and there was no difficulty in seeing clearly all that they did. During July, 1893, whenever I visited this orchard, which I call "No. 4," I found a male and a female rubythroat in attendance upon it.

In July and August, 1890, while watching sapsuckers at what I called orchards "No. 1" and "No. 2," I found that some woodpeckers adopted an entirely different method of dealing with humming birds from that practiced by others. At orchard No. 1 the woodpeckers drove away a humming bird with a marked display of anger whenever one showed itself near the large red maple which was being tapped. At orchard No. 2, on the contrary, the sapsuckers allowed the rubythroats to drink at drills a few inches from their own bills, and resented only marked impertinence on the part of their tiny visitors. At No. 1 scores of visits were paid by humming birds every day, but they reached the drills in a comparatively small number of instances. When they did gain them they drank long and deeply, often perching upon the bark and drinking while their nervous wings were motionless. At No. 2 it seemed impossible to estimate the number of humming birds in attendance. I went so far as to shoot a male and a female in order to feel certain that more than one pair of the tiny birds came to the drills. Nine minutes after my second crime a third humming bird was quietly drinking at the wells. Orchards No. 1 and No. 2 were deserted in or after 1891, their trees for the most part being dead, or so nearly dead as to be unattractive to the sapsuckers. A few rods from No. 2 a new orchard was observed by me in 1892. It may be a direct continuation of No. 2, but as all the woodpeckers at No. 2 were supposed to have been shot in 1890,

the chances are that it is a new settlement. In July, 1893, twenty gray birches within an area a hundred feet square had been scarred by the woodpeckers. About half of these were dead, and out of the entire number only four trees were newly drilled and sap-yielding. In many ways this orchard proved to be the most interesting I have watched. The family of sapsuckers using it was not pugnacious, and in consequence other birds visited it much more freely than is generally the case. Downy woodpeckers occasionally sipped at its fountains; black-and-white creeping warblers regularly, though warily, visited its insect hoards, and during the autumn migration of 1892 a pair of yellow-breasted flycatchers spent many days in constant attendance upon its trees, around which countless insects fluttered or hummed.

The four sap-yielding trees at this orchard appeared in July, 1893, to have been appropriated, subject to the prior claims of the woodpeckers, by three humming birds, a female and two males. No one of these birds permitted either of the others or any one of numerous filibustering humming birds to drink at its pre-empted wells. If trespass was attempted, the most furious assault was made upon the intruder, and the possessor was always victorious. Thus, if the female at the eastern tree attempted to approach the western tree, the male on guard there drove her away; while if he entered upon her dominions, he was swiftly repulsed. The details of these meetings were sometimes very extraordinary. In one instance a visiting female persisted for nearly ten minutes in trying to secure a foothold at the western tree. The savage little male met her with his usual impetuous charge, but she dodged him, and began a strange sinuous flight among the branches, back and forth, up and down, round and through, over and under, until the air seemed filled with pursued and pursuer, dizzily maintaining their mysterious flight within from five to a hundred feet of the disputed drinking place. Much of the time the female seemed to be facing the male and flying backward slowly with head erect; then there would come a swift *buzz-z-z*, and a clear space between the trees would be traversed by both birds with the speed of light, a slower flight being resumed the moment foliage was entered. If the male paused in his pursuit, the female drew near again to the coveted drills, and so forced him to renew the chase. Sometimes they moved so slowly that they seemed like bubbles or airy seed vessels wafted by the breeze, and sometimes they flew in short, ever-changing lines, so that the eye wearied of watching them. At last the female gave up the struggle and vanished above the neighboring tree tops.

Frequently the visitors did not come singly, but arrived two or three together, and made combined attacks upon the drills. Then the air would be filled with violent humming and the most

petulant squeaking, as the possessors hurled themselves first at one intruder and then at another, driving them back and forth, as though playing battledore and shuttlecock with them. Twice I saw the male who defended the western tree lock bills with a visiting female and fall almost to the ground in combat; and in several instances I noticed a hotly pursued visitor escape by suddenly doubling, seizing a twig, and then hanging head downward by one foot behind a cluster of leaves. As a rule, the rubythroat, when drinking, makes a perfectly audible humming, the male making a sound somewhat louder and deeper than that produced by the female. It is, however, entirely within the range of their accomplishments to hover silently, and it is not unusual for a visitor to drink silently when successful in reaching a tree unseen. While I never have seen a male rubythroat drink from the drills while perching, I have noticed the female doing so scores of times. In fact, the female at the eastern tree perched nearly a third of the time, sometimes on a twig from which she could lean over and sip the sap, sometimes on the bark itself in a position almost identical with that taken by the woodpecker.

One morning while I was watching the new orchard, a shower came up from behind the western spurs of Chocorua. Thunder grumbled, the sky grew dark, and the wind swished viciously through the slender birches. I wondered what the birds and insects would do when the rain came. From where I sat, I could see dozens of living things, most of which were more or less dependent upon the sapsuckers' orchard. There were four of the woodpeckers themselves, three humming birds, a hermit thrush, two juncos, three chickadees, a least flycatcher; five or six butterflies representing three species; hornets and numbers of flies, ants, and other small insects. As the rain began, the insects, with the exception of the hornets, vanished at once. All the birds, save one of the woodpeckers and the rubythroats, flew out of sight. The remaining sapsucker was a young bird, who looked stupid, and who received the rain by ducking his head and vibrating his tail and wings as a bird does when he bathes in a pool. But the rubythroats amazed me by their conduct. They sought leafless twigs with only the weeping sky above them, and there, apparently with joy, extended their wings to the fullest extent, spread their tails until every feather showed its point, and then received the pelting, pounding rain as though it were holy water. They became so wet that I doubted whether they could fly. *Buzz-z-z!* the vigilant male darted at an intruding female and drove her out of sight, only to see her return again and again in the thickest of the white drops in vain attempts to overcome his watchfulness. It was evident that no ordinary shower could interfere with the whirring wings of a humming bird.

As the season of 1893 wore on, the number of humming birds at this orchard diminished. Late in July I saw as many as five birds near the trees at one moment, three of them being regular attendants and two interlopers. During the next four weeks I was absent, but on my return I found that only the female using the eastern tree remained, and that she was seldom annoyed by visitors. The trees which had been used by the other two birds had run dry, and the sapsuckers as well as their uninvited guests had abandoned them. Of the identity of the remaining humming bird there could be no question; her ways were too strongly marked to be mistaken, as, for example, her invariable habit of alighting upon one slightly sloping trunk when she drank from its drills. When September drew near I watched closely to ascertain the date of the little lady's departure, but day after day came and went without my missing her. At last, on September 1st, it seemed to me that she had gone. I had waited ten or fifteen minutes by the trees and she had not come, though the sapsuckers were busy at the drills in their accustomed places. Before finally giving her up I thought that I would count a hundred slowly and see if this form of incantation might not draw her to her trees. When I reached "ninety-nine" and no bird came, I concluded that the exact date of her migration had been found, but as I said "one hundred" there was a faint hum in the still air, and the dainty dipper appeared with her usual sprightliness. On the 6th, after several light frosts had laid their chilly touch upon the Chocorua country, I felt confident that the tiny creature must have sought a kinder climate. Again, however, she surprised me by appearing, after a long delay, as bright as ever. She hummed at her regular drinking places, but seemed to find little moisture in the wasting fountains. The trees were losing vitality and becoming dry. Then she sought the dead twigs at the tops of last year's trees and flitted back and forth among them, sunning herself. No perch pleased her long, and when she wearied of them all she darted back to the drills for a brief perfunctory sip of the slow-moving sap. Her restlessness seemed born of the season, and a symptom of that fever of migration which was making all bird life throb more and more quickly.

Although on September 25th, when I made my last visit of the year to the orchard, I found two sapsuckers still at work at the drills, no humming bird was with them. How long after the 6th the vigorous little female remained I do not know, for I was unable to watch the trees during the middle of the month.

Although at Chocorua I never have found a sapsuckers' orchard without its attendant humming birds, I am by no means sure that in other localities where both birds occur the same interesting community of interests is to be detected. During a brief

visit to Cape Breton in midsummer, 1893, I kept close watch for sapsuckers and humming birds. Of the latter not one came under my eyes, although common testimony was that they frequented the country. Of the sapsuckers I found one flourishing colony among the alders which bordered the southwest Margaree at the point where that swift stream emerges from Lake Ainslie. More than a dozen alder trunks had been girdled with drills and a rich orchard seemed to be in use. I had not long to wait at the spot, but in the fifteen minutes which I could spare no humming birds came to reward my silent watching.

In some parts of the country sapsuckers are roughly treated on account of their destruction of trees. It is unquestionably true that each family of birds kills one or more vigorous trees each year, but generally the trees are small and of trifling value as timber. My sapsuckers are welcome to several forest trees a year, so long as they continue to attract and feed humming birds, and indirectly to draw thousands of insects within easy reach of their own bills and the more active mandibles of flycatchers, warblers, and vireos.

BARBERRIES: A STUDY OF USES AND ORIGINS.

By FREDERICK LE ROY SARGENT.

THE common barberry (*Berberis vulgaris*), being so abundant over the greater part of Europe, native to the soil, and at the same time both useful and beautiful, has naturally come to hold an important place in popular esteem. As a consequence it has received, in the course of centuries, a considerable variety of names in the different European languages, and some of these names, as might be expected, have undergone rather curious transformations.

Our own name *barberry* is in England more commonly written *berberry*. The variants *barbary*, *barbery*, and *berbery* were used side by side in early modern English, as were *barbere* in still earlier English and *berbere* in the French of that time. There can be no doubt that these are descended from the mediæval Latin forms *barberis* and *berberis*, but further back than this the pedigree is uncertain.

In the change of the terminal from *beris* to *berry* we have, doubtless, an example of one of those transformations which are so apt to take place whenever the foreign name of a common object becomes incorporated into the vernacular, and the sound of the name suggests a common word in any way descriptive of the object. Just as the *écrevisse* (crevice-dweller) of the French became the "crayfish" of the English, from its aquatic habits,

and the *asparagus* of the botanist is the "sparrergrass" or "sparrowgrass" of the marketman, so we may conclude that the character of the barberry's fruit decided the change of name referred to.

The first syllable of the English name is, doubtless, as unmeaning as the corresponding part of "crayfish," or its rival form "crawfish." Perhaps in both these cases the lack of any signifi-

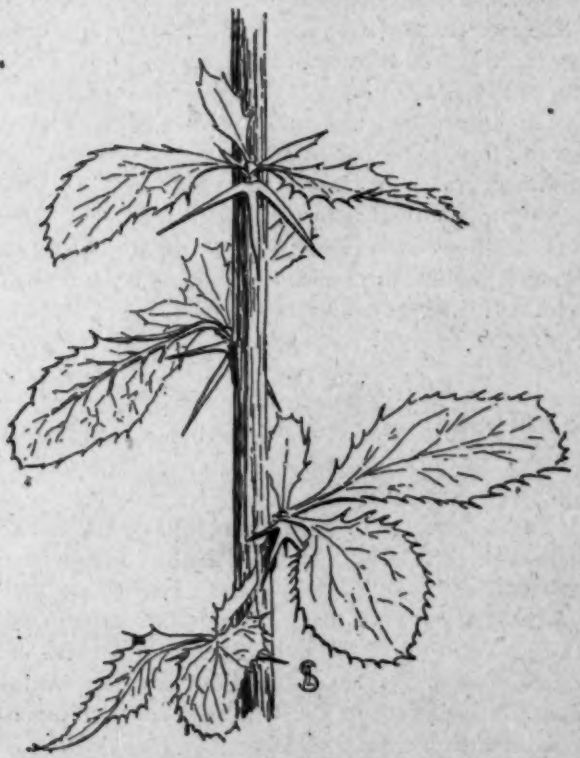

FIG. 1.—BERBERIS VULGARIS. Part of a long shoot, showing four spines and as many short branches bearing leaf rosettes.

cance in the first part of the words may have favored the continuance of two forms side by side.

Various conjectures have been offered as to the origin of the mediæval Latin *barberis* and *berberis*. Most commonly the Latin name is said to be derived from the Arabic *barbārīs* or *berbērys*;* but, according to Murray and the Century Dictionary, the Arabic form and the Persian *barbari* are both derivatives of the Latin. Wittstein † suggests a derivation from the Greek *berberi*, a mussel, from the mussel-like form of the leaves. The conjecture which assumes the plant to have been imported into Europe

* Gray's Manual, sixth edition.

† Etym. bot. Handwörterbuch, 1856.

from Barbary, in Africa, does not harmonize well with what is known of the plant's distribution.

To return, then, to the Latin form, however it may have originated, we find it giving rise to the English *berberry* in a manner suggestive of adaptation to a new linguistic environment. By a somewhat similar process have probably arisen from the same original the form *pepperidge, pipperage, piperidge,* and *piprage,* by which the plant is popularly known in parts of England and Ireland. The ease with which the closely similar sounds *b* and *p* can pass one into the other, taken in connection with the obvious resemblance of the barbery fruit to small red peppers, doubtless gave direction here to the obscure forces which bring about the corruption of words.

The same Latin root makes its appearance in several names used in Germany. Thus, among those given by Adelung (1774) are *Berbeisze, Berbis, Berwitze.* The name most commonly met with in modern books is *Berberitze,* which, in view of the circumstance that *ritzen* means to scratch (apropos of the spines), surely looks like another case of assimilation, analogous to what we found in English. That the Germans are fond of embodying in their names of this plant some reference to its more or less obvious qualities or uses is sufficiently proved by the following list gathered from various lexicons: *Sauerdorn* (sour thorn), *Essigdorn* (vinegar thorn), *Weinschierling* (wine hemlock), *Weinnäglein,* wine clove), *Weinäuglein* (wine eye), *Kreuzdorn* (cross thorn), and so on.

FIG. 2.—BERBERIS VULGARIS. A leaf rosette and flower cluster.

In French, besides the older *berbere,* and the form *berberis,* which is in common use to-day, we have *épine-vinette,* which Littré considers may have been given to the plant either because of its clusters of berries, resembling grapes, or because a sort of tart berry wine is made from them, or else because of its acidity, *vinette* being in many provinces the name of sorrels, sour grapes, and the like. This last supposition would make the name a counterpart of the German *Sauerdorn.*

The Spanish *berberis* and the Italian *berberi* do not, of course, call for any special explanation. Without attempting to make a complete list of the names which have been applied to this plant,

enough have been given to show that, at least in the history of those forms cognate with our own *barberry*, there are presented not a few curious and perhaps significant analogies with the evolution of a group of organic species subjected to the diverse influences of changing environment.

Leaving now the matter of names, let us proceed to consider the plant itself, and, so far as may be, something of its history.

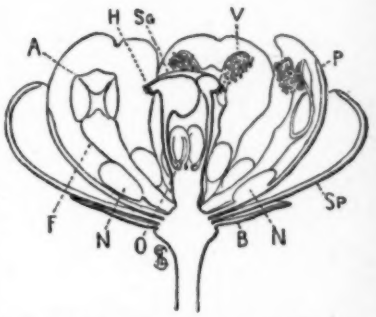

FIG. 3.—BERBERIS VULGARIS. Vertical section of flower: B, bract; Sp, sepal; P, petal; N, N, nectar glands; F, filament; A, anther; V, valve; So, stigma; H, zone of hairs; O, ovule.

The barberry's place in Nature is expressed botanically by saying that it belongs to the principal genus of the family *Berberidaceæ*, and is thus near of kin to our native "twinleaf" (*Jeffersonia*), "cohosh" (*Caulophyllum*), and "May apple" (*Podophyllum*). As will be seen by referring to Fig. 3, the floral structure is, like theirs, notably simple and regular, and the parts are all distinct, thus recalling the general features to be found in the buttercup family (*Ranunculaceæ*) and the moonseed family (*Menispermaceæ*). It evidently is of the same ancestral stock as these, since they all agree so closely in fundamental plan, despite innumerable differences in matters of comparatively small detail. Moreover, the intense yellow color so generally characteristic of the tissues of *Berberidaceæ*, depending, as is well known, upon the presence of the bitter alkaloid *berberine* ($C_{20}H_{17}NO_4$), occurs also to some extent in the families mentioned. Hence the structural evidences of consanguinity gain something of confirmation in the fact that we find the same substance which renders various species of *Berberis* useful for medicinal and tinctorial purposes imparting its tonic properties and intense yellow to the "goldthread" (*Coptis*) and "yellowroot" (*Xanthorrhiza*) among *Ranunculaceæ*, and the "calumba root" (*Jateorrhiza*) of *Menispermaceæ*.

In the old days of belief in "signatures," this yellowness of the barberry's tissues was taken as a sure indication that here must be a sovereign remedy for jaundice, and accordingly a decoction of the bark was in high repute as a specific for that disease. While this notion has, of course, long been banished to the limbo of imaginary medicine, yet, in the modern practice, decoctions, infusions, and the fluid extract of barberry bark, as well as the isolated alkaloid berberine, have a recognized tonic value. It is an aqueous extract prepared in India from the sliced roots and branches of the so-called "ophthalmic barberry" (*Berberis ly-*

cium), and other Himalayan species, which constitutes the highly valued "rusot."

Considered from the plant's standpoint, this bitter principle, so abundantly present in its outer tissues, is doubtless to be regarded as a defense against gnawing animals, and as such, accessory to the spines which can be effective as a protection only against the larger animals which feed upon leaves. Thus, as often happens with the plants of our pharmacopœia, the very means adopted for its preservation becomes the object of its being destroyed for man's use.

But the barberry has more to contend against than the attacks of animals. As a native of regions visited by heavy storms of snow and wind, its branch system (often eight to ten feet in height), even though it be rid of its leaves through the winter, must, nevertheless, be subjected to a very considerable

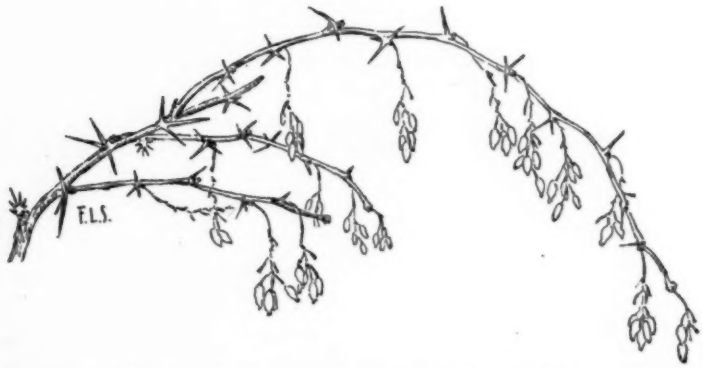

FIG. 4.—BERBERIS VULGARIS. Leafless branches, showing clusters of fruit and different forms of spines.

mechanical strain. A glance at the vegetative organs of our plant will show with what efficiency and economy of material this bit of engineering is accomplished.

First of all it will be noticed that there are two remarkably different sorts of branches (compare Figs. 1 and 4). The one sort, long, slender, and arching, are armed with the stout spines already referred to; while the others, originating from the axils of these spines, remain very short, although bearing year after year, through the summer, each a rosette of leaves. All who have observed the effect upon our trees and shrubs of one of those storms which load everything with snow and ice must have seen that the plants which received least damage were those in which there was either unusual stoutness of material or else such an attitude and flexibility in the branches as enabled them to bend readily under a load or other strain. Now, in the branch system of the barberry bush we find all these character-

istics most happily combined; for, thanks to the plant's economy in making the rosette branches so short, an abundance of material is available for the construction of those elongated ones which are to perform the special work of mechanical support.

In the course of its first year one of these elaborately organized shoots may attain a length of two feet or even more. During this rapid growth only a little wood is formed, but in the young bark there are developed about a dozen strands of tough, elastic fiber, which show as prominent ridges at the surface. These strands continue for a year or so to impart such strength and elasticity to the branch that when bent downward, even to a radius of two or three inches, it will spring back to its original curve. After the second or third year the bark and its fibers become brittle and weak through wear, but in the meantime the wood within, at first so meager, has been increasing, ring upon ring, around the central pith, so that, before the bark has ceased to be of mechanical service, there has already been formed to take its place a tissue possessing fully as much elasticity as the other, and in addition remarkable toughness and durability. These qualities are even more apparent as the wood grows older; so much so, indeed, that it is highly valued in turnery and the manufacture of archers' bows. Thus we see that when a storm comes, the barberry can meet the emergency with branches which yield gracefully so long as they are young, but with age become most effectively resistant.

Still, a moment's consideration of the distribution of strain will show that for all this flexibility and stoutness throughout the length of the branches a serious dismemberment of the plant must ensue if the place of juncture between each long branch and its trunk be not strongly re-enforced. Now, the long branches of the barberry arise each as a continuation of the axis of a rosette branch. While these short branches have only a cluster of leaves to support, they are but weak, brittle affairs, composed chiefly of soft pith with only a sparse supply of woody fibers; but when the short axis comes to serve as the basal part of a long shoot, not only does the wood increase remarkably, but even the pith becomes hard and firm. Moreover, we find throughout the whole plant that, whenever a branch is called upon to sustain a considerable load, its base is proportionately thickened and strengthened, and the same is true to a marked degree of the main trunk at its juncture with the root.

Although with us barberry bushes are for the most part denizens of the open, in Europe they are reported as often growing at the margin of woods. When in this situation, the branches become much more elongated, and, by using the recurved spines as grappling hooks, they climb over the shrubbery encompassing

the tree trunks, and finally gain support upon the branches of the trees themselves. Unlike ordinary vines, however, which only injure the plants that support them, the barberry may be of some service, as its armament of spines is well calculated to repel intruders.

FIG. 5.—BERBERIS AQUIFOLIUM. Leaves and branches.

The great aim of all this spread and strengthening of branch work is of course to secure the most advantageous exposure of foliage to light; to the attainment of this object the form and arrangement of the leaves themselves also contribute not a little. Wherever we find such rosettes of wedge-shaped leaves as the barberry produces, the likelihood of one leaf overshadowing its neighbor is much reduced, and when as in shady localities this matter is of special importance, it is a noteworthy fact that the leaves commonly adapt themselves to each other so perfectly that a cluster becomes almost equivalent to a single large shield-shaped blade. Moreover, on the more horizontal shoots the margins of contiguous rosettes dovetail into each other so neatly that the result may be justly compared to a mosaic of leaves.

Another peculiarity connected with that abbreviation of the branchlets which results in the rosette arrangement is the method of defoliation. When the time arrives, the leaves, instead of separating entirely, drop only the blade, while the flattened overlapping leafstalks remain attached to the stem and perform the function of bark for several years.

It will thus be seen that we have in the barberry one of those rare cases (paralleled by certain species of orange, grapevine, and creeper) in which an apparently simple leaf has the blade articulated with the stalk after the manner so characteristic of the leaflets of compound leaves (Fig. 8). Of the hundred or more known species of *Berberis*, about twenty (forming the subgenus *Mahonia*) have compound leaves of from three to many leaflets all plainly articulated at the base (Figs. 6 and 7), just as is also the case with certain species of the genera *Citrus* and *Vitis*, to which the orange and the grape respectively belong. Moreover, throughout the *Berberidaceæ* we find almost all the species to pos-

sess leaves which are obviously compound, the chief exception being those eighty species (forming the subgenus *Euberberis*) which in their leaves agree essentially with *Berberis vulgaris*. In view of these facts, botanists have been led to adopt the somewhat paradoxical theory that leaves of the euberberis type are in reality compound though unifoliolate.

The question as to how such a curious state of things could have come about is so closely connected with what concerns the evolution of the other vegetative organs that we shall do well to consider them all together.

In attempting to reconstruct for ourselves the main features of the original ancestral barberry we are much helped by the fact that besides *Berberis vulgaris*, which is the only representative of the genus in central Europe, there have been developed a multitude of species in Asia and a still larger number in the two Americas; for it is clear that this must considerably increase the chances of our being able to find something like the primitive form persisting in certain living species. Guided by the principle that evolution is for the most part attended by increase of differ-

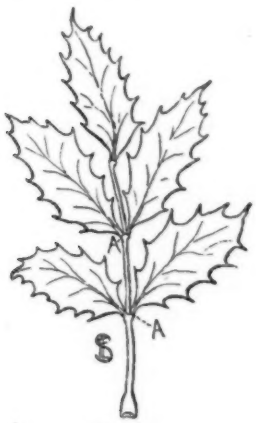

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 6.—Berberis aquifolium. Quinquifoliolate leaf.
Fig. 7.—Berberis trifoliata. Trifoliolate leaf.
Fig. 8.—Berberis vulgaris. Unifoliolate leaf. A indicates the point of articulation of the leaflet.

entiation, we may fairly assume that the branch system of the prototype differed from *Berberis vulgaris* in having the internodes approximately equal, thus making the lateral branches on the one hand and the main branches on the other more nearly of a length and all the leaves uniformly disposed in elongated spirals.

Such a condition is indeed tolerably well exhibited in the mahonias, as may be seen in the "holly-leaved barberry" (Fig. 5),

which is a fair example of the *Mahonia* group. At the same time it is worthy of note that along with the greater uniformity of the branches is associated the possession of compound leaves having from three to many leaflets. This fact, taken in connection with the circumstance that almost all the other members of the family have the leaves more or less plainly of the palmate type, makes it probable that the ancestor of the barberries had trifoliolate leaves not unlike those often found interspersed among the larger leaves of the multifoliate mahonias and appearing also as the sole form on other species of the same subgenus (compare Figs. 5 and 7). It is significant, moreover, that the mahonias are without the highly developed spines so characteristic of the *Euberberides*, but depend for protection upon the spiny margins of their evergreen leaflets.

Thus, whether we consider the approach toward similarity among the branches, the approximation in the type of leaf to that most common in the family, or the absence of specialized spines, we are led to the conclusion that the *Mahoniæ* since they exhibit so much less differentiation than the *Euberberides*, must therefore represent more nearly the primitive features of the genus—a conclusion which is confirmed by such paleontological evidence as we possess. For the five species discovered in the Tertiary formation of southern France, northern Italy, and Switzerland are all mahonias, one of them (*Berberis helvetica*) closely resembling the American holly-leaved mahonia here figured, while others are like forms living at present in China. In view of these facts we shall probably be not far from the truth if we picture to ourselves the ancestral *Berberis* as being a small bush or underbrush resembling in a general way our evergreen holly, but having in place of each simple leaf a compound one of three leaflets. Almost exactly corresponding to this description is the already mentioned *Berberis* (*Mahonia*) *trifoliata* of Mexico and the adjacent regions.

That the ancestral home of the barberries was most probably in the northern part of North America appears from what is known of the geographical distribution of the species when viewed in the light of the generalizations arrived at by Bentham, Hooker, and Asa Gray regarding the origination of the members of the north temperate flora. We learn from Bentham that "to the great majority of them no primeval antiquity can be ascribed in central or western Europe; they appear to have come from the East, a considerable number perhaps from western Asia, where their types appear to be more varied, but many also must have made half the tour of the globe. Large American genera have sent out offsets into eastern Asia, which, gradually diminishing in number of species and sometimes slightly modifying their character, have

spread over the whole of Asia, and invaded almost every part of Europe."* Of these latter genera *Berberis* is surely one.

Geologists tell us that the climate even of arctic America during the Mesozoic era was as warm and equable as that of our Southern States to-day. The same was true of northern Europe and Asia, and there is good reason to believe that between the latter and America there was during Mesozoic times a continuous land connection in high latitudes, or at least a chain of islands uniting the two continents. Such were the conditions then under which we may suppose a berberidaceous herb to have acquired the shrubbiness and other characteristics which distinguish barberries from the rest of the family.

As the descendants of this trifoliolated, woody form multiplied and spread over the vast territory open to them, the modifications which arose must have progressed along two principal lines of development. The first to diverge was doubtless the line of pinnate-leaved mahonias. To explain the development of such a leaf from the trifoliolate ancestral form, we have only to suppose the terminal leaflet to become stalked and then divided into three, just as we must conceive the trifoliolate leaf to have been derived in the first place from a sessile, simple-bladed one. From such trichotomy of the terminal leaflet would result a five-foliolated leaf (Fig. 6); but let the process be repeated with successive terminal leaflets a sufficient number of times, and the most highly developed mahonia leaf is readily accounted for. This view accounts, moreover, for the curious circumstance that in these leaves there is, in addition to the articulation between leaflet and rhachis, a transverse articulation extending across the rhachis between each pair of leaflets (Fig. 6 A). For what can this be but the representative of that terminal articulation which was once at the base of a leaflet since differentiated into all those parts of the leaf now lying above the articulation?

Along with the multiplication of leaflets there appears to have been a lessening of the number of leaves and some shortening of the branches, which affected the lateral ones somewhat more than the primary axes; but beyond this the changes introduced concerned only matters of small detail. The descendants of this new form spread into Asia and thence into Europe, where we find some remains of them in the deposits of the Tertiary. Subsequently, in the course of that general lowering of temperature which culminated in the Glacial period, these pinnate-leaved species were exterminated in Europe, while in Asia and America, where a more southerly extension into warmer regions was possible, they were able to survive and spread northward again after the retreat of

* Nat. Hist. Review, p. 370.

the glacier and so take up their home in the localities we find them to-day. That such a form as *Berberis trifoliata*, which retains so fully the primitive characteristics, should remain in Mexico, seems to find a sufficient explanation in the fact that the climate of this region resembles most closely that of its supposed northern home in preglacial times; or, in other words, we may look upon the persistence of the original form as connected with the continuation of similar climatic conditions during the life of the species from the time when the genus first appeared.

While the ancestors of our modern mahonias were seeking an asylum in lower latitudes, certain other descendants of the primitive trifoliolate barberry were in all probability enabled to hold their own much longer against the encroaching cold, by developing those adaptations to extremes of temperature which make the various forms of euberberis so well suited to their present home.

We have already seen the advantages which come with differentiation of the branch system when plants are to be subjected to the storms of a severe winter. Such differentiation, however, means not only a more efficient disposition of the mechanical elements in the stem part of the plant, but it involves a closer and closer crowding of the leaves on the shorter branches until the limit of crowding is reached in the rosette. Obviously trifoliolate leaves are ill suited for such an arrangement—the lateral leaflets would be so much in the way. The causes which bring about the reduction and final disappearance of parts that have become useless or harmful to a species could not fail, therefore, to affect these leaflets until the present unifoliolate condition was reached. Moreover, in the absence of lateral leaflets there would be less need for an elongated leafstalk, and we should expect, therefore, just such an abbreviation of this organ as we actually find in a large share of the species of euberberis. We have already noticed how this enables *Berberis vulgaris* to turn its petioles to good account, by keeping them as protective bark scales long after the leaf blades have fallen.

It is in harmony with our conclusion that the ancestral barberry was a holly-like plant, whose descendants became modified under the influence of gradual refrigeration, to suppose that the earlier forms of euberberis were evergreen. So far as their migrations enabled them to continue living under conditions of climate favorable to the retention of leaves throughout the year, this habit might be expected to be present. This we find is the case with species in central Asia and in the mountainous and temperate parts of South America. Even in a region of much snow and ice no serious disadvantages need be feared, provided the plant does not extend its branches far above the ground. This will doubtless explain the presence of the evergreen mahonia

undershrubs in our Western States, as well as other apparent exceptions among *Berberides* to the general principle we are now applying.

Along with the firm texture belonging to evergreen leaves there would naturally be retained the marginal spines which protected the mahonia ancestors from browsing animals. But with the establishment of the rosette arrangement the leaves which are borne by a long shoot, in virtue of their position just below the rosettes, come to have a special importance in this protective capacity. For, in the first place, as being already fully developed at a time when the rosette leaves are young and tender, the old leaves can shield the newer ones at the most critical period of their life; and, in the second place, given one stout, spiny leaf in such intimate connection with the mature cluster, and the need for using up material in spine-making for the latter is much lessened. Accordingly, we find very generally throughout the evergreen *Euberberides*, along with the differentiation of the branches into long and short, a differentiation of the leaves—those subtending the clusters being decidedly spiny, while those of the cluster are less strongly armed. A particularly good example of such differentiation not far advanced is afforded by a species growing in Chili (Fig. 9). In a number of cases, such as the "box-leaved barberry" (*Berberis buxifolia*, Fig. 10), the differentiation has been carried so far that the subtending leaf has been completely transformed into a formidable spine, while the rosette leaves have lost all trace of spines except at the tip.

FIG. 9.—BERBERIS TOMENTOSA (?). Leaf rosettes subtended by stouter spiny leaves.

After the plurifoliolate and the unifoliolate types of evergreen barberries had been evolved there was the further possibility of developing from the latter a yet higher type which should be still better adapted to meet the exigencies of a severe and snowy winter, and at the same time safely attain a considerable height. All this would follow from the acquirement of the deciduous habit.

In the series of forms which came to adopt the expedient of defoliation at the approach of winter, several causes may have conspired to bring about in the two sorts of leaves a still further specialization of the two functions of assimilation and defense, which, originally combined in each leaf, began, as we have seen, to be separated more or less in the evergreen *Euberberides*.

As regards the subtending leaves, not only would their importance as a defense to the young rosette be sufficient to insure their

persistence through the winter, but the same reason which made the defoliation of the rosette advantageous—namely, decrease of the surface on which snow might lodge—would favor a reduction of lateral spread in the persisting leaf blades. Moreover, assimilation could not, of course, be carried on during the winter, and so the green parts of the leaf could well be spared to afford the material necessary for making the spines firmer and longer. Thus would finally result a purely defensive organ, so much the more efficient because having no other function to perform. Our common barberry exhibits especially well (Figs. 11 and 4) not only the more highly developed spines, but the intermediate stages connecting these with the primitive spiny leaf. Toward the tip of the uppermost shoots we find slender, one-pronged spines; the next below these are three-pronged, while those toward the base of the same shoot may have the prongs five or more in number. Passing now to one of those shoots, known as "suckers," which spring from older (mostly subterranean) parts of the plant, we find in addition to the forms of spines already noticed, others (Fig. 11, A–D) in which foliar characteristics become more and more evident as we approach the base of the shoot, where occur spiny leaves (A) essentially like what we have assumed to be the ancestral form. In regard to the position which these different forms occupy in relation to the ground or to their proximate basis of support, it is worthy of note how nicely all this accords with the theory of their having been developed under the influence of snowy winters.

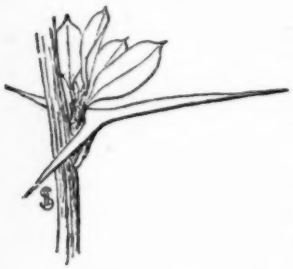

FIG. 10.—BERBERIS BUXIFOLIA. Leaf rosette and spine.

To the rosette leaves the limiting of their duration to the warmer part of the year would permit a much thinner texture than was formerly necessary, and in consequence a more extended spread. This would of course involve a corresponding weakening of the marginal spines, but these being now so fully superseded in function, might safely be reduced to such slender cilia as we now find on the leaves of our common barberry (Fig. 8), or indeed be done away with altogether, as not infrequently happens in the same plant. They are clearly rudimentary organs tending to disappear.

A further consequence of the increasing severity of climate was the need of some special means to protect the tender organs of the bud against harmful changes of temperature. So long as these changes were comparatively slight and one set of leaves remained in place while the others were developing, the sheathing bases of the former served as a loose protective covering which answered every purpose. This supplementary function obviously

fell to the lot of the last-formed or uppermost leaves of the set. As need arose for better protection of the infant shoots, the simplest way of meeting it would be to increase the efficiency of the parts already in use by widening them as far as might be necessary. As this was going on, the same fate which overtook the lateral leaflets of the original three would now extend to the terminal one of each of these upper leaves; for with the shortening of the stem they would be brought to lie so closely above the others as to shade them injuriously if not reduced in size. Moreover, as being the latest to develop, they would get but a small share of the reserve food provided for the rosette. Still, their relation to the supply of nutriment as well as their uselessness or power for harm in the rosette would, after all, be more a matter of degree than in the case of the lateral leaflets, since these latter would have to lie practically in one plane and so must interfere not only with the terminal leaflets but with each other. This may help us to explain why, although the lateral leaflets have so en-

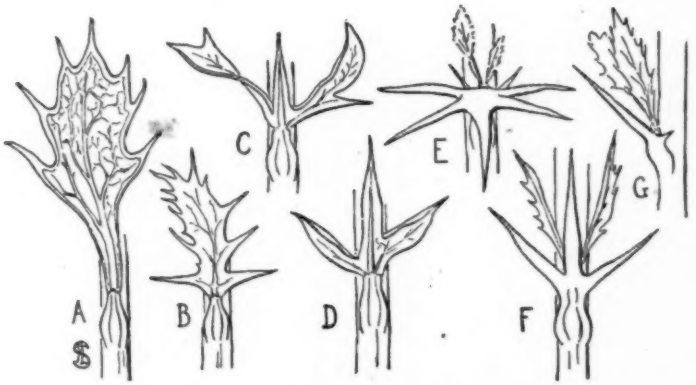

FIG. 11.—BERBERIS VULGARIS. Series of spiny leaves passing into spines.

tirely disappeared, we still find on some of the lower bud scales traces of a blade which thus afford connecting links in our morphological chain (Fig. 12).

This evolution of the bud scales must, of course, have been closely connected with that shortening of the petiole which we have already noticed in the typical rosette leaves as having culminated in the production of persistent overlapping scales forming an outer bark for the secondary branches; and it would seem most probable that the development of bud scales and bark scales proceeded side by side. Finally, as accounting further for their similarity of form, it may be remarked that in both, the protective function, at first merely incidental to that of mechanical support, comes at length to be the sole use for which they are retained: in one case it is a matter of years, in the other of generations.

For the propagation of barberries gardeners often take advantage of those adventitious shoots or "suckers" before mentioned which spring from near or beneath the surface of the ground. These, separated from the parent and planted in suitable soil, strike root after the manner of a willow twig and develop into a shrub. With wild barberries, if the main part of the shrub happens to be fatally injured, suckers proceeding from parts of the root even remote from the stem may continue to live and thus perpetuate the stock in the same locality.

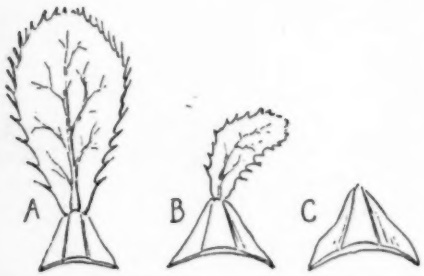

FIG. 12.—BERBERIS VULGARIS. Transition forms connecting foliage leaf with bud scale.

In Nature, however, it is upon seedlings that the chief dependence is placed for the continuance and spread of the species. Having now considered, as fully as present limits will permit, the phenomena connected with the barberries' vegetative life, we will next turn our attention to the special peculiarities of flower and fruit which contribute more or less directly to the production and care of offspring.

[*To be concluded.*]

COMMERCIAL POWER DEVELOPMENT AT NIAGARA.

BY ERNEST A. LE SUEUR.

AS many of the readers of The Popular Science Monthly are aware, there is a great engineering project on foot at Niagara Falls, looking to the development of a part of the water power at present running to waste over the gigantic cataract. A company, or rather an association of companies, working for a common end, is at present occupied at the falls with the object in view of utilizing the power commercially.

That this situation is the finest in the world for developing mechanical power has long been realized, but the local demands at Niagara were comparatively trifling, and only lately have our facilities for transmitting power over distances become sufficiently developed to warrant such an undertaking as is now in hand. The power company does not, however, look entirely to distant points for consumers of their output; on the contrary, a very large amount will be used almost on the spot by manufactures which are now moving to Niagara. The variety of purposes to which this power will be put may be gathered from the

fact that they are as diverse as the manufacture of "mechanical" wood pulp and the smelting of aluminum.

There are already at the falls a few establishments using power developed by turbines, and which have been quietly at work for years. There is a canal known as the Hydraulic Canal on the American side, skirting the city of Niagara Falls, and terminating on the cliffs, half a mile below the cataract. There are a number of mills here which, for the most part, however, utilize only a fraction of the total fall available, probably for the reason that when they were built there were not in existence the high-grade water wheels suitable for great head that are on the market to-day.

People in general have the idea that the Niagara water power is inexhaustible, and so it probably is, so far as human requirements go. There are, however, some tolerably close data on which to figure the total horse power. The Lake Survey Board and Mr. R. C. Reid, examining the matter independently, have come to a very fair agreement in their conclusions on this point. From their figures it would appear that the average flow is about 270,000 cubic feet per second, and this is almost exactly the same as the almost unthinkable quantity of 1,000,000,000 pounds per minute. A horse power of work is the equivalent of 33,000 foot pounds per minute, and as the weight above mentioned falls 161 feet, the horse power of the total is expressed as follows: $161 \times 1{,}000{,}000{,}000 \div 33{,}000 =$ close on five million.

Owing to the lack in full efficiency of even the best commercial turbine wheels, we may take the limit of power that could be developed as about 4,000,000 horse power.

The average power is not departed from to any great extent at different seasons, as is the case with other water powers, because the spring thaws and summer droughts affect hardly at all the level of Lake Erie, from which the falls get their supply.

The system of Great Lakes above Ontario would require a year in order to have their level reduced by three feet and a half by even the enormous drain of a thousand million pounds of water per minute above referred to, supposing the system to be entirely cut off from its normal supply. A paper by Mr. R. C. Reid before the Royal Scottish Society of Arts in March, 1885, gives the folling data: Total water-shed area down to Niagara, 290,000 square miles; total lake surface, 92,000 square miles; average rainfall in the lake district, thirty-six inches—and that we may assume twenty inches annually of evaporation and absorption, leaving sixteen inches over the whole area finding its way to the lakes. From the lake surface proper, there occurs evaporation to the extent of twenty-four inches per annum. Further, in reference to the enormous storage capacity of the system, he shows

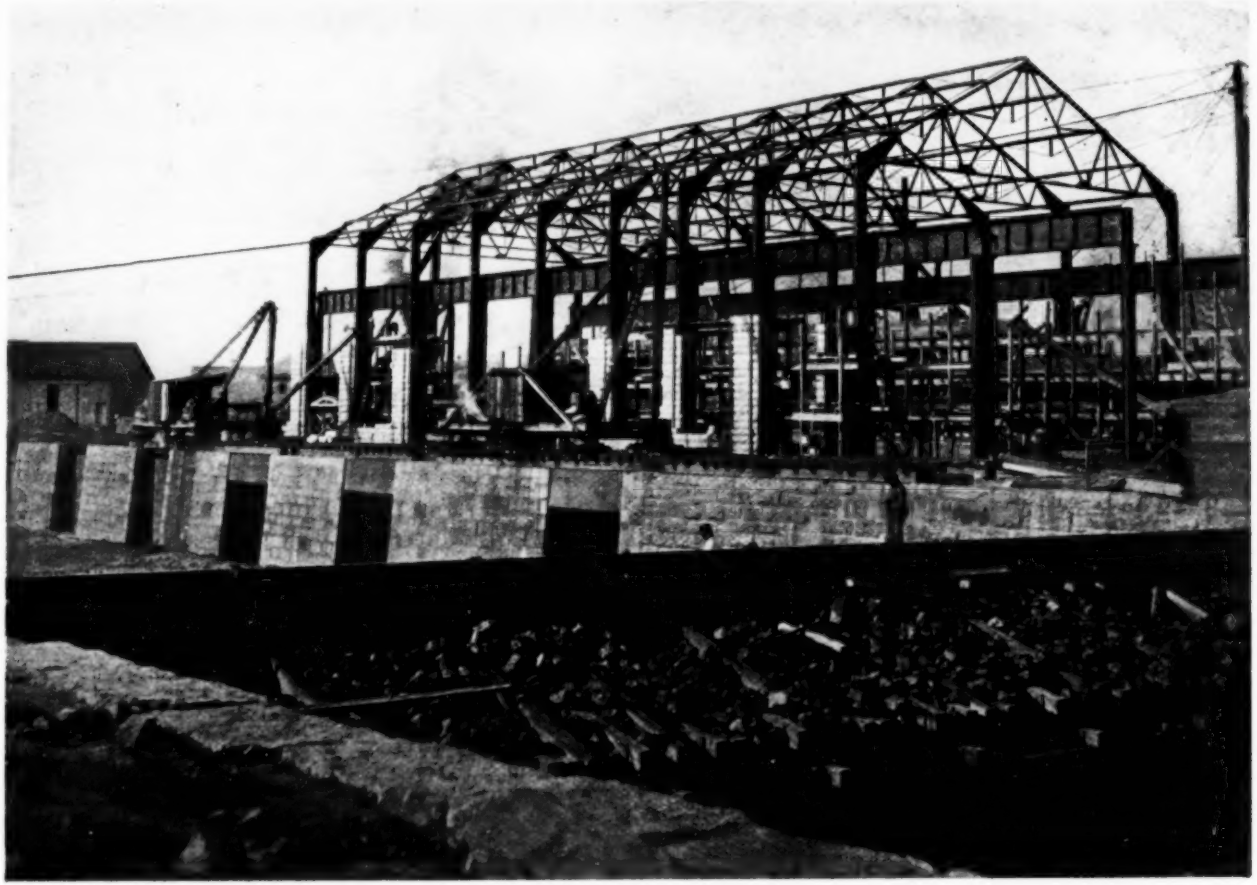

FIG. 1.—SKELETON OF THE POWER HOUSE.

that "it would take six months for the full effect of a flood in Lake Superior to be spent at Niagara Falls." It is easy, therefore, to understand how little fluctuation of level there can be due to seasonal variation in rainfall. Thus we see that quite apart from the fact of the vast volume and head available, and of there being no necessity for building a dam to back up the water, the situation is peculiarly favorable to the development of a constant power all the year round.

In spite of the generally equable level of Lake Erie, there are sometimes very considerable fluctuations, not of volume, but of distribution, due to high winds sweeping the length of the lake and causing a considerable banking of water at the end blown into. Sometimes such storms have lasted for days, and have had a very noticeable effect in increasing or diminishing the volume going over the fall. A more serious cause of low water is an ice jam at the head of the Niagara River. It is on record that in March, 1847, the water practically ceased to flow, "not enough going over to turn a grindstone," as a local paper had it at the time. These two circumstances do not, however, affect the evenness of flow to any extent worth mentioning compared with the seasonal variations in rivers in general.

The total fall between Lakes Erie and Ontario is three hundred and twenty-nine feet, and is made up as follows: From Lake Erie to the head of the falls, seventy feet; the falls, one hundred and sixty-one feet, and below to Lake Ontario, ninety-eight feet. Consequently, the total power running to waste is more than double the five million horse power on the falls. An idea of the proportion that this total bears to what may be called the world's consumption of power may be had from the fact that it is computed to be equal to the total of all the steam-generated power in the world.

The geographical situation of the falls with respect to nearness to the at present great power-consuming centers is, as hinted above, not quite all that could be desired; but there are, nevertheless, several cities within reach, electrically speaking, which will use an enormous amount. Buffalo may be said to be next door, and Rochester is within easy reach. In the not too distant future we may expect to see the great electrical manufacturing works in Schenectady operated, as is meet, by electrical power from Niagara.

The power company has, however, made branch track connections between the territory owned by it and three important railway lines which all pass within a few miles of the property. These connections and the good freight rates which have been contracted for in various directions, together with the cheapness of power, will in all likelihood attract to the spot manufactures

besides those which have already undertaken to go there, to an extent that will make it the foremost power-consuming center in the world.

The chief piece of work in connection with the power installation has been the construction of what, in almost any other situation, would be termed the tailrace. In this case the head utilized is so great that what is ordinarily understood by a tailrace would be an artificial chasm of abysmal proportions that would almost require illumination other than the natural to be visible to the bottom at midday. Instead, a tunnel has been excavated, of which

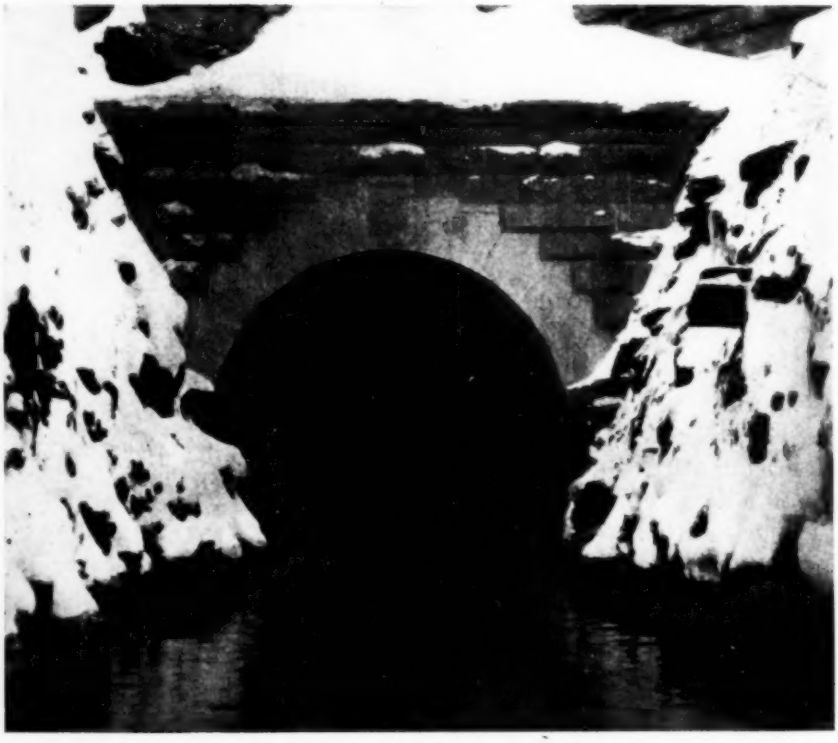

FIG. 2.—OPEN END OF TAIL-RACE TUNNEL.

the dimensions are so remarkable as to make it unique among engineering exploits of the kind.

The location of the power house, on account of difficulty in acquiring sufficient adjacent lands and rights of way and for other reasons, is not very close to the falls. The Cataract Construction Company has established itself about a mile and a half above the American Fall, and has dug a canal of considerable width, of a depth of twelve feet, and length fifteen hundred feet. Along its edge for a distance of at present one hundred and forty feet is dug a great trench or slot one hundred and sixty feet

down, with arrangements in the form of gates in the masonry wall separating it from the canal, by which water may be admitted to penstocks placed vertically in the slot and supplying the turbine wheels. A penstock, as many of our readers are aware, is a great tube, usually, in these days, of boiler plate, of a diameter running up, it may be, to thirteen feet, conveying water under head into the wheel case in which the turbine revolves.

In the present instance the penstocks, which are seven and a half feet in diameter, seem very small, considering that they each supply a pair of wheels of five thousand horse power, but that is on account of the enormous pressure under which the wheels work, giving a greater power for a given volume of water than with the smaller heads more commonly used.

The turbines discharge their waste water into the tunnel above referred to, which is no less than six thousand seven hundred feet long, and which discharges into the chasm below the falls just past the Suspension Bridge.

The details of this tunnel, which was excavated through three shafts, one in the face of the cliff and two vertical ones, are as follows: Length, six thousand seven hundred feet, and sectional area three hundred and eighty-six square feet throughout, the average height and width being about twenty-one and nineteen feet respectively. The cross-section somewhat resembles a horseshoe. The excavation was much larger than the finished inside dimensions, on account of the subsequent lining with four courses of brick. The mouth of the tunnel has, besides, a lining on the top and sides of iron. The work has been done most substantially and is built to stay. The tunneling was done through strata of limestone and shale, and harder material was met with than had been expected in the beginning, so that the three million cubic feet of excavation has cut a very important figure in the total cost of the power plant. The tunnel has a grade of 0·7 per cent (seven feet fall per thousand length), and runs directly under the city of Niagara Falls to the lower river level.

The work of excavation was carried on on three benches, dividing the total height of twenty-six feet about into three equal portions.

The whole undertaking has been so entirely novel in many ways that the engineers in charge have had their resources taxed to the utmost in overcoming the various difficulties that presented themselves during the design and construction of the power house, electrical and hydraulic apparatus, and tunnel. The power-house building is as yet of comparatively small proportions, but is intended to be enlarged as the number of dynamos and turbines is increased. It might be thought, and was thought at first by some of the projectors of the scheme, that the great amount of power

that was to be developed would admit of considerable subdivision, not only of the units of power production (each unit consisting of a turbine and generator), but also of the ways in which the electrical power would best be sent out to consumers.

As already mentioned, a number of manufacturing establishments are locating themselves on the property owned by the Cataract Construction Company, and to these it would at first sight seem natural and best to deliver electrical power straight from the power-house generators to their motors, seeing that this could easily be done without much loss of voltage on the carrying line; and, on the other hand, for distant work, as at Buffalo and Roch-

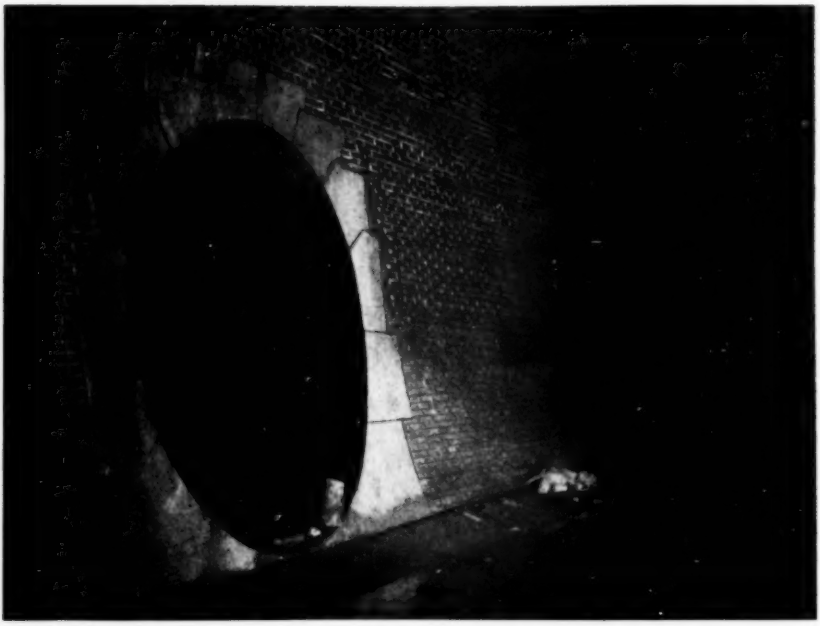

FIG. 3.—INTERIOR OF LARGE MAIN TUNNEL, SHOWING JUNCTION OF LATERAL TUNNEL FROM NIAGARA PAPER COMPANY'S WHEEL PIT.

ester, to use a high potential on the line with transformers at the consuming end or at both ends. It has, however, been decided not to thus take advantage of the mechanical subdivision of the plant to use different types of generators for different kinds of work, but to adopt as a standard one good form of machine and use it throughout, at least until the plant is increased.

Perhaps the most remarkable consequence of this step will be that the Pittsburg Reduction Company, which manufactures metallic aluminum by the action of electricity upon certain compounds of that metal in a state of fusion, and which expects to use some thousands of electrical horse power when established at the falls, will receive it in the form of an alternating current,

which will be passed into an alternating-current motor driving a direct-current, low-voltage generator furnishing at last the desired electrolyzing current. It has seemed best to submit to this complication of apparatus in order to gain the advantage of entire uniformity and interchangeability of power units in the generating plant. Of course, if the power company were to put in a direct-current dynamo for the benefit of the Reduction Company, all that would be necessary would be to send the current over a wire straight to its work; and it seems remarkable, in view of the thousands of horse power required, that the extra expense of a motor and dynamo to transform this quantity appears preferable.

The electrical power unit which has been decided on after the most exhaustive, and presumably competent, expert examination of the requirements of the situation, will be of a capacity for continuous work of five thousand electrical horse power (or three thousand seven hundred kilowatts), and will be directly connected with a pair of turbines of similar power. All the generators will be mechanically identical in construction and have parts interchangeable with each other. The advantage of this, besides the obvious one of having a single set of spare parts suffice against the breakdown of any machine in the station, is that, from a point of view of the electrical aspect of the case, of the machines being able all to be put in parallel, as it is called. The expression may not be a familiar one to some of our readers, and the following hydraulic analogy may be of service in leading to an understanding of what is meant by it. Let us assume that we have several pumping engines of equal power, and that we are using them all to pump water from one reservoir into another at a higher level. Obviously the total amount of water pumped will be what a single machine handles multiplied by the number of them. Had, say, one of the pumps been weaker than the others—had it, that is, not been strong enough to force water up to the height that the others did—the result would be that, instead of doing any work when put, as we may say, in parallel with the others, it would have been unable to withstand the head, and water would have forced itself back through it into the lower reservoir. The same way with dynamos, or generators as they are usually called when referring to the machinery in a power as distinct from a lighting station. The advantage of working in parallel is, that if we have, say, six machines all "pumping" current into the same mains and one breaks down, we may take it out of circuit, and, by temporarily overloading the other five, which can always be done for a short time with good machines, keep on supplying full current to consumers. Should the power company have decided to put in a special machine for aluminum, and other special ones for other local work, and still more for distant work,

each would have its own circuit, and, if it broke down, the whole dependent system would be idle until repairs were completed. One of the great aims of the company appears to be to insure the permanence and continuousness of their power service—which is, of course, of the utmost importance to manufacturers.

A remarkable method of construction—not, however, unique—is employed in the generators to secure means for direct coupling to the turbine shafts. These latter are vertical, and come up over one hundred and forty feet out of the wheel pits from the rotating water wheels, which make two hundred and fifty revolutions per minute. In order to obtain direct driving—that is, without the intervention of toothed or friction gearing, or belt or rope driving—the revolving portions of the generator are arranged to rotate in a horizontal instead of, as is usual, a vertical plane.

A dynamo of any type whatever consists, as is well known, essentially of two portions, one of which possesses motion with respect to the other, viz., the armature and the field magnets. Since the field magnets are almost invariably much heavier and much less compact than the armature, the latter is usually chosen as the moving part. In the case under discussion the contrary has been decided on, the armature being fixed and the field magnets rotating. This gives certain advantages in the matter of less complicated electrical connections and of dispensing with the armature's rubbing collectors altogether; it also gives the advantage—much more important in this case than with smaller machines—that, since the revolving magnets are arranged on a ring and point inward, the attraction between them and the armature core tends toward neutralization of the strains of centrifugal force. The greatest advantage, however, attained by this method, and again one which is of far greater value in the present case than in ordinary practice, is the high degree of insulation possible with fixed armature coils and connections. The requirements that had to be met in the way of limiting the centrifugal strains were that the product of the sum of the weights of the revolving parts in pounds and the square of their velocities in feet per second should not exceed eleven hundred million. The weight of the moving parts of each dynamo was also limited to eighty thousand pounds, while the weight of the turbine and its shaft amounts to seventy-two thousand pounds.

This whole weight of seventy-six tons acts in one vertical line—i. e., that of the turbine shaft—and revolves two hundred and fifty times per minute. It would have been very difficult to construct thrust bearings to take up the whole of this strain, and a hydraulic balancing piston has been resorted to for supporting it. This device is simply a circular piston fast on the vertical turbine shaft, set in a vertical cylinder. The supporting force consists of

FIG. 4.—COMMENCEMENT OF WORK ON SLOT (WHEEL PIT).

hydraulic pressure admitted to the under side of the piston. This pressure is derived simply from the water in the penstock supplied to the turbine, and when the latter is working under full gate—that is, is taking water to its full capacity—the pressure in the penstock is decidedly less, just as the pressure in a water pipe is partly relieved by the opening of a faucet. This causes the supporting force on the under side of the piston to materially decrease, and a thrust bearing—that is, a bearing adapted to withstand either pressure or pull, so as to hold the shaft against the tendency to end play—has to be resorted to in order to take up the difference. As a matter of fact, the difference between the supporting force when the flow is a minimum and that when the gate is wide open is about two tons in the seventy-six. The way this is handled is to arrange the area of the piston and the depth below the upper water level so that at minimum flow the supporting pressure will be about one ton more than the total weight, and at full gate about the same amount less. At the normal rate of working there is very little to be taken up by the thrust bearings.

An idea of the magnitude of the proportions of the generators may be gathered from the fact that the designers were limited in the size of base plates that they could use by the inability of the railways to transport, even by especially large and powerful cars, pieces of proportions originally designed from the factories to he falls.

It is stated that, had it not been for the tariff restrictions imposed on the importation of electrical machinery, the generators would probably have been purchased abroad. As it was, they, as well as the motors which will operate on their circuits, are the work of a great Pittsburg company. In the case of the turbines the design was by a Geneva firm, and the construction mainly done in Philadelphia. Certain of the fittings are French, and the governors Swiss.

One of the details in the power house is a traveling crane capable of handling pieces weighing up to fifty tons, which commands every portion of the floor of the building. The presence of this piece of apparatus is of the greatest importance in the case of anything going wrong with one of the generators or turbines. With its assistance any portion of either of these ponderous pieces of mechanism which may need repair can be moved with the greatest expedition, and a spare interchangeable part put in its place. Frequently in an installation of heavy machinery, although perhaps much less ponderous than these in question, a break occurs which may cause a shut-down of many hours, when, if sufficiently powerful means of moving heavy parts were at hand, the damaged piece could be replaced in a

comparatively short time. A traveling crane of this description, as most of our readers are aware, consists of a long carriage having a pair of rails on which runs the crane truck carrying the lifting machinery. The long carriage, which is supported a suitable height above the floor, stretches across the width of space to be commanded, and itself has a sideway movement on several supporting rails which run the length of the space to be operated over. Thus by a combination of the two movements the crane truck commands the whole floor.

During the work of assembling the penstocks, wheel cases, turbines, etc., at the wheel pit, a view of this great slot with its contents was wonderfully impressive in giving an idea of the vastness of the whole enterprise. The great depth of this long, narrow pit, which made it impossible to see to the bottom except with the assistance of lamps in the lower part, the mysterious-looking pipes (the penstocks) rising vertically, new sections being constantly added much in the same way that a stovepipe is put together, except for the permanence given by the heavy riveted seams, and the enormous power and flexibility of operation of the immense traveling crane which rapidly conveyed in every direction great masses of iron and steel obedient to the turn of a switch, made a combination of impressive effects not quickly forgotten.

To obtain an idea of just what the relation to each other of the various parts in the installation is, the reader is referred to the sketches numbered 6, 7, and 8.

It may be mentioned that, to withstand the very considerable hydraulic pressure at the lower part of the penstocks, these tubes are built of thicker and thicker plates from the top downward.

There has been very little criticism of the mechanical details of construction so far referred to; on the contrary, very little can be said except in praise of the fertility of resource and high general competence of the engineers who have had this work in hand. With regard, however, to the particular design of the generators from an electrical rather than a mechanical standpoint much and lavish criticism, if not condemnation, has appeared in various quarters. Whether the grounds for this criticism are well founded or not it would be presumptuous at this time to attempt to declare, but we may say that where, as in this case, one man has had practically the entire control of the design of the electrical apparatus, we may usually look for, rather than be surprised at, a great amount of setting up of individual opinion against the views which he may embody in practice, often a good deal irrespective of the probably cogent reasons which may have induced him to adopt the course in question.

Without attempting to decide between the various views which are plentifully to hand in criticism of certain electrical

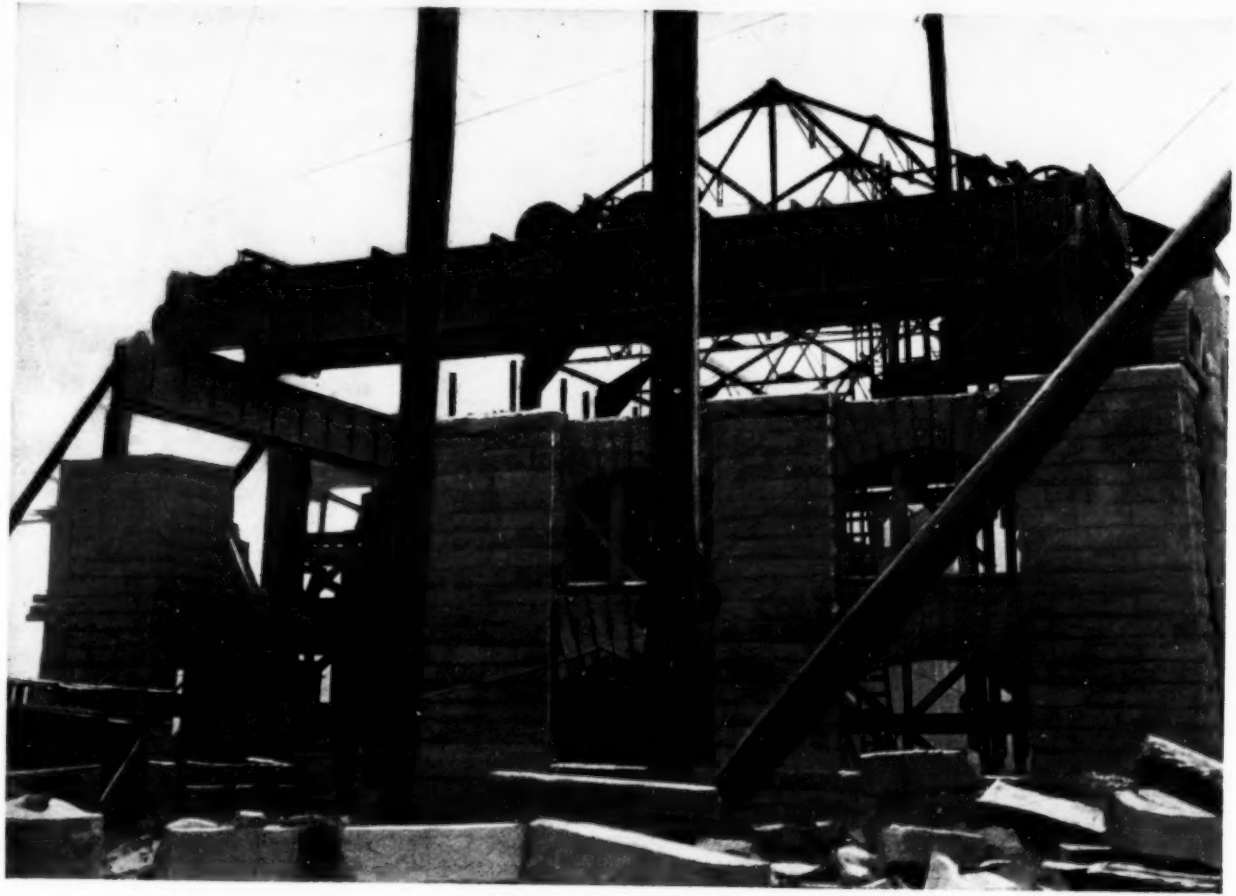

FIG. 5.—TRAVELING CRANE.

details in the design and proposed method of utilizing the current of the generators, we may glance at what has been decided on, and review the more important points raised in connection therewith.

In the first place, the use of an alternating as opposed to a direct current was decided on, as was to have been expected. The development within the last year or two of alternating-current motors has rendered possible the distribution of electricity for power (as opposed to lighting) purposes over distances before almost out of the question. It has been for a number of years past possible to transmit large quantities of electrical energy for lighting which was not suitable for running the then known motors. The method of electrical distribution for lighting purposes that is used in cities is available also for transmission to considerable distances. It consists, as is well known, of a dynamo supplying current at a high voltage to the street lines, and a system of transformers each taking a portion of this current at high voltage and giving in return a current of greater ampèrage or volume and of lower voltage for house consumption, the object being simply to avoid loss of voltage or pressure by transmitting a heavy current over a light wire. As this may not be quite clear to every reader, it may be as well to say a little more about it.

The energy of any current is determined by and is equal to the product of two of its properties, its volume or ampèrage and its pressure or voltage. Letting C represent the ampères and V the voltage, we have that the energy = C V. In passing any current over any wire there is a loss of voltage determined by and equal to the product of two things—i. e., the ampèrage of the current and the resistance of the wire; so we have loss of voltage = C R. Now, if we have two currents—one, say, of ten ampères and one volt, and the other of one ampère and ten volts—the energy will be the same, or ten watts as it is called. If we pass both through a given resistance, R, we shall have a loss of voltage (= C R) ten times greater in the first than in the second case. But a given loss of voltage amounts to only one tenth as much energy (C V) in the second case with C = one ampère as it does in the first with C = ten ampères, so that with only one tenth the given loss of voltage the energy lost will be only one one-hundredth that lost in the first case. What it amounts to is that the loss in passing a given amount of electrical energy through a given resistance is proportional to the square of the current, or ampèrage, and consequently inversely proportional to the square of the pressure, or voltage.

If, therefore, current is used in a house at fifty volts and transmitted to the house at one thousand volts, the loss will be

only one four-hundredth as much over a given wire as it would be if transmitted at fifty volts.

The advantage that alternating currents have over direct for long-distance transmission is that they may easily be transformed up or down—that is, their voltage at the generating end may be increased (at the expense, of course, of their ampèrage) and reduced at the consuming end. In point of fact, it is frequently and usually unnecessary to employ such devices at the generating end, for the reason that the generators themselves can work perfectly well at the high voltage requisite to transmit. The objection to using the same high voltage on the consuming machinery is simply that there is more danger of accident with numerous small motors scattered in various places and in the hands of unskilled persons than in a power station containing only two or three highly guarded machines attended by trained operatives.

With this fact of the possibility of generating currents of a voltage suitable for immediate transmission, it at first sight appears strange that direct-current transmission is not a more common thing than it is. The method of the so-called "motor transformer," "rotary transformer," or "dynamotor," might be adopted. A transmission plant working on this method would operate as follows: The power station would contain preferably several highly insulated direct-current generators, all of similar construction, for very high potential (four thousand volts would be easily obtained); these would run in series—that is, each would add its voltage to that of the others, and there would preferably be a spare machine to substitute for any one of the others which might become injured. If four machines were in series, the resultant current would be put to line at, say, sixteen thousand volts, would be received at the other end by a number of motors, also in series, which in their turn would drive low potential dynamos supplying current for local use.

There are two objections to this as compared with alternating-current transmission: One is the fact that there has grown up a very tangible, we may almost call it, superstition against the use of high-voltage direct-current machines of large size among very many electricians. The reasons for this are not difficult to trace; prominent among them being the simple fact that no commercial application has ever yet required such machines. The only high-potential direct-current dynamos are those used for arc lighting, and on account of the great subdivision of arc-lighting circuits the units of generation are invariably small, at least by comparison with the ponderous machinery used in the Niagara Falls power plant.

There is no reason why they could not be made large (in point of fact, arc-lighting requirements are continually making demands

for the construction of larger and larger machines, and the requirements are just as steadily being met without difficulty), and yet this very tangible dislike of their use for power transmission undoubtedly exists. The result is that, without undertaking considerable work on new ground in the way of patterns, designs, etc., no company could obtain such machines; and since the alternating current has had practically the exclusive attention of the laborers in the field of electrical power transmission there is no

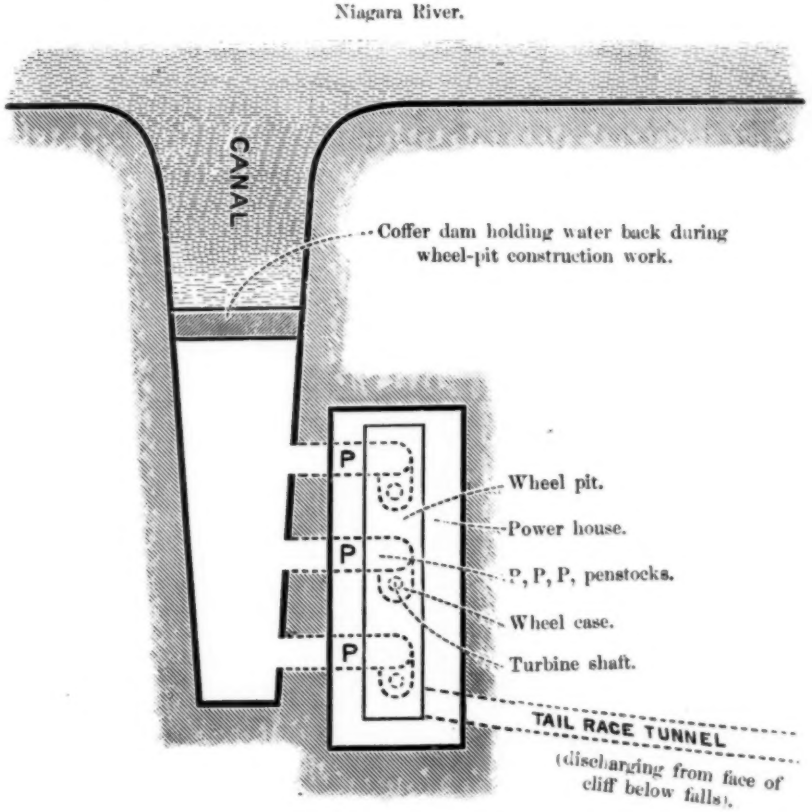

FIG. 6.—RIVER, CANAL, WHEEL PIT, AND TAIL-RACE TUNNEL.

method, tried on the large scale, for the other. The second disadvantage referred to is the greater cost of motor transformers over the simple stationary ones for alternating work. In view, however, of the fact of the proposed installation of these very motor transformers in adapting the alternating current to the arc lighting of Buffalo, and to the aluminum smelting works at Niagara, it would seem that this objection could not count for very much.

In connection with the Niagara Falls work there is the further

advantage which the alternating current has over the direct, and that is what may be termed the "flexibility," commercially, of the former. The alternating-current machines operated in parallel at, say, two thousand volts, may have a portion of their current taken from them at that voltage for use in the immediate neighborhood and the rest transformed up for distant transmission.

The advantages of the direct-current system would be two: First, the simpler methods of motor operation by its means, and the availability of the current for electrochemical work and storage-battery operation direct. Second, the smaller weight of copper necessary on the transmitting wire, for the three reasons of the evenness of flow, the absence of self-induction on the line, and the absence of skin resistance in direct-current transmission. The effects of the two latter phenomena will be discussed later.

Inventive effort has, singularly, stayed in the rut of work on alternating-current transmission, and in attempting anything on the scale of the Niagara Falls undertaking it would be perilous, even had it been considered for other reasons advisable, to depart more than necessary from usual practice.

Lately, and particularly owing to the brilliant work of a young man, a native of Smiljan Lika, a border country of Austria-Hungary, by name Nikola Tesla, there have been devised forms of apparatus, generating as well as consuming, by means of which alternating currents may be economically used for operating motors. To express it very roughly, his method amounts to arranging an armature within a magnetic ring and causing opposite magnetic poles to revolve around the ring so as to cause rotation of the armature.

The operation of these devices is preferably by means of a polyphase alternating current—that is, a flow of electricity having more than one pulsating current.

Before finally deciding on what system of transmission to use, the Cataract Construction Company asked for plans for a system for the purpose from a number of electrical engineering establishments. Twenty-four distinct ones were submitted, more than one of the tendering companies having sent several different plans to be chosen from. No individual one was, however, accepted *in toto*, but instead a design was adopted embodying such points of value as could be assembled in one suitable type of machine, and the Westinghouse Company received the contract for it. The system on which the generators work is the Tesla two-phase, and is notably peculiar on account of the low periodicity of alternation.

The number of pulsations of commercial alternating currents is usually over one hundred per second and is frequently double

that amount. The reasons for this high frequency are mainly two: The first, that with any given alternating-current dynamo the number of alternations depends directly on the speed, and, as this must usually be high in order to get as much work as possible out of the machine, the periodicity is also high. The second reason is that in lighting work it is, of course, highly undesirable to employ a current of which the pulsations are so slow as to leave the incandescent filament or the arc visibly dimmer between separate beats, as we may call them, than during the passage of the full current strength. In the case in hand one is impressed with the effort that has been made to steer a middle course in the design of the generators so as to obtain a portion of

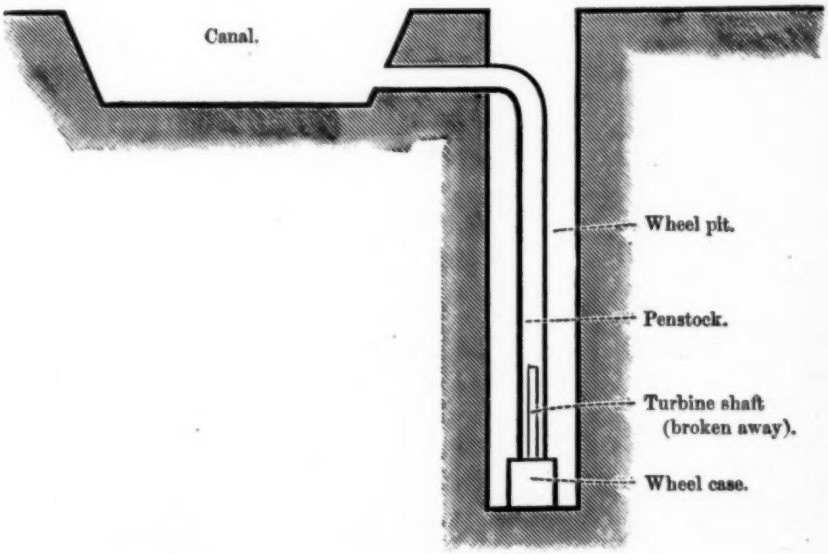

FIG. 7.—ELEVATION (PART SECTION) OF WHEEL CASE, PIT, AND PENSTOCK.

the advantage of the direct current for motor work and of the alternating for transformation. The periodicity for the first portion at least of the electrical equipment is to be as low as twenty-five per second, and this at once limits the scope of the use of the current in the matter of electric lighting. Prof. Forbes states that lighting by the current direct is a comparatively small portion of the work in contemplation, and that the plant is rather to be regarded as essentially for power distribution. The expression, "lighting by the current direct," is used because a very important branch of the power work will be the lighting of the city of Buffalo. This is at present done by the ordinary direct-current arc machines operated by engines of some three thousand horse power. In changing over to the Niagara Falls power the whole

electrical system will be untouched, but the engines will be replaced by motors operated by current from the falls station.

As has been justified by the importance of the subject, there have been some quite exhaustive experiments undertaken by various scientists to determine the frequency of alternation at which unsteadiness of the light from both incandescent and arc lamps is observable or at least objectionable. Several independent experimenters have arrived at results sufficiently satisfactory to themselves, but which unfortunately can not be used as reliable data, for the reason that they are highly discrepant with each other. One reason for this is the evident one of the difference between different makes of lamps, but the discrepancies are of a character not altogether to be explained on that ground. With the ordinary fifty-volt filament, however, it would seem that we may place the working rate of alternation at about thirty or over; with arc lamps, at about fifty or over.

As above mentioned, the arc lighting will be done by making use of the motor transformer (a motor operated by the power current driving a dynamo generating, if we may call it so, the secondary current), but it is expected that by means of a special form of incandescent lamp—the Bernstein, which has, indeed, been on the market for several years—the twenty-five-period current will be available for direct use for illumination by means of incandescent lamps. It is evident that the thicker the filament the longer will its incandescence take to die out (as well as to start up), and a current of twenty-five pulsations, which may not be available for the high-resistance (thin) filament, may be quite sufficiently so for a low-resistance one, which the Bernstein lamp above mentioned is.

The voltage at which the first installation of generators is to operate is somewhat over two thousand. Considering the perfection to which European practice has been carried in the construction of alternating-current machines for much higher electrical pressures than the above, it seems strange that this voltage should have been decided on in a situation where one would expect the very highest degree of perfection to be attained. It is stated, however, that it was largely on account of the comparatively backward condition of that branch of electrical engineering construction in America that the voltage had to be placed so low.

In a case like the present one, where the power station will be under the supervision of skilled engineers, and not merely of men whose chief qualifications are those of sobriety and an ability to stay awake at night, there appears no sufficient reason why the generators should not be operated at five times the voltage named. The fact of the armatures in these machines being fixed gives, moreover, additional security against danger consequent on such

high voltage on account of the very much more perfect insulation possible.

The advantage, of course, of using a very high electrical pressure lies in the principle stated above of the loss in sending a given amount of energy over a given wire being inversely proportional to the square of the voltage.

By the use of step-up transformers it will, of course, be possible to transmit at any voltage that the insulation of the line can withstand; but if this high voltage could be reached by the machines directly, the loss (we may liken it to a friction loss in machinery) of efficiency in the transformers, and, even more important, the great cost of that part of the equipment, would both be avoided.

What will be done will be to use these step-up transformers and put current on the transmitting line at about twenty thousand volts; it is likely, however, that in any subsequent enlargements of the generating plant the three original machines will be used for local work only, and a radical change made in the direction of an enormously higher generated voltage.

Intimately associated with this question is the problem of how to convey current at this tremendous potential of twenty thousand volts to distances. An idea of what it means may be had from the facts that two thousand is relied on to be sufficient to instantly kill a human being, and that the energy of a current given up in passing through any given resistance varies as the square of the voltage.

The chief difficulty to be met in such line construction is that of efficiently insulating the wires. If one attempted to use a line insulated merely as an ordinary telegraph line is, there would be an enormous loss, amounting practically to the whole of the transmitted current, in moist weather, by leakage over the damp surfaces of the glass or other insulators. The remedy for this leakage would, however, be a comparatively simple matter by means of well-known oil-holding arrangements for the insulators were it not for the further fact that it is imperatively necessary not to have the two wires, the going and return ones, farther apart than can not be avoided on account of what are known as the effects of self-induction. The wires strung on telegraph poles would have to be so far apart in order to insure their never, by any possibility, coming in contact, that the self-induction losses would make that method impracticable.

The self-induction of a circuit has the effect of retarding both the starting up and the dying out of a current flowing in the circuit. The phenomenon gives a resemblance of the possession of a property analogous to mechanical inertia to the current. Since inertia, however, is a property dependent solely on the mass of a

body, and is the same for all situations or conditions of the body, we shall see that self-induction has but a very faint likeness to it, for self-induction is a property of a conducting path or circuit, and not at all of the current. To dip lightly into the theory of the phenomenon, we may say that the inception or the stoppage of an electrical flow in any conductor involves the starting up or stoppage of a movement in the dielectric medium surrounding the conductor. The time requisite for this movement to start up or stop gives a perfect analogue to mechanical inertia. If, now, we have a circuit consisting of a wire returning on itself, the two halves being as close together as they may be without touching, we see that a flow starting up in this wire means a current in each half in opposite directions. For the present it suffices to say that the effect above referred to of the starting up of a movement in the surrounding medium is rendered less and less by the canceling effect of the opposite electrical flows the nearer the two halves of the circuit are brought together.

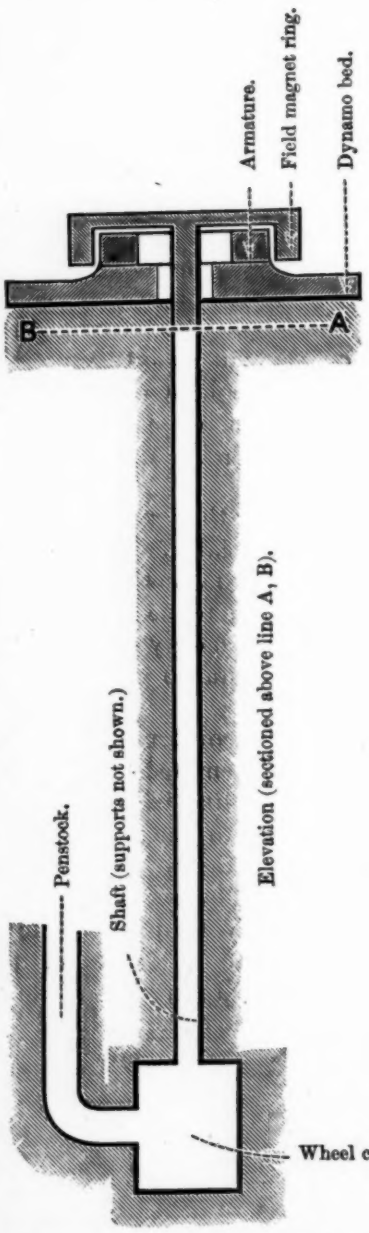

FIG. 8.—WHEEL CASE, SHAFT, AND DYNAMO.

The evil effects of self-induction are directly proportional to the number of alternations of the current in a given time, and consequently the twenty-five-period current adopted for the Niagara Falls work is highly advantageous from this point of view.

The so-called "skin resistance" of an alternating-current circuit is, in brief, due to the fact that an alternating current penetrates only a short distance into

the body of the metal of which the carrying wire is composed, instead of, as in the case of a direct current, flowing across the whole cross-section of the wire in an even manner. This also is less serious the lower the periodicity. In the case of a lightning flash (which is an alternating-current discharge) the periodicity is enormously high, and it is known that in its flow over wires it travels almost entirely through the mere surface skin of the metal. It may be mentioned here, as having possibly a very important bearing on work such as that under discussion, that a most remarkable claim has recently been brought forth that bimetallic wires, or wires of one metal coated with a different one on the outside, give remarkably improved results for the conduction of alternating currents over the conductivities of the two metals in the weights used, laid together as separate wires.

The form decided on in which to construct the conveying lines is that of a conduit or subway of large proportions. One which has been already constructed for a length of half a mile is as follows: The walls are arched, and the width is greatest at about two thirds of the height. The conductors are carried on insulated brackets along the sides, spaced at intervals of thirty feet. The subway is lined with concrete, and manholes at intervals allow of access; besides, there are small pieces of pipe let in at the bottoms of the manhole ducts for the purpose of inserting such wires as may from time to time be required to tap the line conductors. The subway is five and a half feet high and three feet ten inches wide. A track runs along it, and the line inspectors will make their trips on an electrically propelled car; heavy wire screens the height of the subway, extending on both sides of the track, protecting the occupants from any possible discharge from the main conductors.

The Cataract Construction Company expect to be able to deliver power in Buffalo at a cost per horse power, for twenty-four hours a day yearly, greatly below the cost of steam power as now produced in Buffalo with coal at one dollar and a half per ton. The generators are expected to operate at five thousand horse power each, with an efficiency of ninety-eight per cent on the power delivered to them by the turbines, and there will be only three and a half per cent drop of pressure in transmitting at twenty thousand volts to the northern part of Buffalo. This last appears wonderful when we consider that it is less than the drop from the generators of an electric railway system to the motors of cars within as short a distance as half a mile, quite apart, moreover, from the extra losses in the latter case due to imperfect trolley contacts. It is hoped also to transmit power before long to the Erie Canal, on which at the close of last season there was an interesting development in the line of electrical

canal-boat propulsion. What else may be in store for the closing years of the century in still further applications of transmitted electrical power, notably in the displacement of steam in railroad operation, can only be foreshadowed. Suffice it to say that the Niagara Falls Power Company will probably soon find their initial fifteen thousand horse-power equipment entirely insufficient to meet the demands upon it.

SCIENTIFIC EDUCATION.*

By Dr. H. E. ARMSTRONG, F. R. S.

ENGLISH boys and girls at the present day are the victims of excessive lesson learning, and are also falling a prey, in increasing numbers year by year, to the examination-demon, which threatens to become by far the most ruthless monster the world has ever known either in fact or in fable. Ask any teacher who has to do with students fresh from school his opinion of them: he will say that in the great majority of cases they have little if any power of helping themselves, little desire to learn about things, little if any observing power, little desire to reason on what they see or are called on to witness; that they are destitute of the sense of accuracy, and satisfied with any performance, however slovenly; that, in short, they are neither inquisitive nor acquisitive, and as they too often are idle as well, the opportunities offered to them are blindly sacrificed. A considerable proportion undoubtedly are by nature mentally very feeble; but the larger number are by no means without ability, and are, in fact, victims of an acquired disease. We *must* find a remedy for this state of things, or perish in the face of the terrific competition now setting in. Boys and girls at school must be taught from the very earliest moment to *do* and to *appreciate*. It is of no use our teaching them merely *about* things, however interesting—no facts must be taught *without their use* being taught simultaneously; and, as far as possible, they must be led to discover the facts for themselves. Instead of our placing condensed summaries in their hands, we must lead them to use works of reference and acquire the habit of finding out; they must always be at work applying their knowledge and solving problems. It is a libel on the human race to say, as many do, that children can not think and reason, and that they can only be taught facts; early childhood is the time at which these faculties are most apparent, and it is probably

* From the Presidential Address delivered at the Chemical Society (Great Britain), on March 22, 1894.

through failure to exercise them then that they suffer atrophy. The so-called science introduced into a few schools in answer to the persistent demands of its advocates has been in most cases a shallow fraud, of no value whatever educationally. Boys see oxygen made and things burned in it, which gives them much pleasure; but, after all, this is but the old lesson learning in an interesting shape, and has no superior *educational* effect. I would here repeat what I have recently urged elsewhere, that in the future *all subjects* must be taught *scientifically* at school, in order to inculcate those habits of mind which are termed scientific habits; the teaching of *scientific method*—not the mere shibboleths of some branch of natural science—must be insisted on. No doubt some branch of chemistry, with a due modicum of physics, etc., is the subject by means of which we may best instill the scientific habits associated with experimental studies, but it must be the true chemistry of the discoverer, not the cookery-book-receipt pseudo-form which has so long usurped its place. Whatever be taught, let me repeat that mere repetition work and lesson learning *must* give place to a system of allowing children to *do* things themselves. Should we succeed in infusing the research spirit into our teaching generally, then there will be hope that, in the course of a generation or so, we shall cease to be the Philistines we are at the present time; the education given in our schools will be worthy of being named a "*liberal education*," which it never will be so long as we worship the old world classical fetich, and allow our schools to be controlled by those who reverence this alone, having never been instructed in a wider faith.

As regards our college courses, I see no reason to modify the views expressed in my address to the Chemical Section of the British Association at Aberdeen in 1885; on the contrary, the experience I have since gained as a teacher and examiner has served only to strengthen them and to convince me of the paramount necessity of a very radical change in our system of instruction, and I rejoice at the increasing evidence of a state of unrest both at home and abroad. The "thorough" course of qualitative analysis which it has long been customary to impose at a very early period of the student's career must, I venture to think, be relegated to near its close; this course certainly has not the effect of producing competent analysts, and but too often reduces those who toil through it to the dead level of machines; in hundreds of cases I have seen students, as it were, hang up their intelligence on the clothes peg outside and enter the examination room masked with a set of analytical tables, through which alone they allow themselves to be actuated, and to which they render the blindest obedience. Qualitative analysis actually requires the fullest exercise of the mental faculties as well as considerable manip-

ulative skill. By introducing this branch of study at too early a period we force our students to act as machines, inasmuch as they do not, and can not, know enough to work intelligently; we are but trying to make them run before they have learned to walk. Even when the interactions on which qualitative analysis is based are fully studied, and the equations relating thereto are conscientiously written out, the result is not much better, owing to the slight importance of so many of the interactions apart from their technical application in analysis, and especially on account of our ignorance of the precise nature of many of the interchanges of which we avail ourselves: the persistent misrepresentation of facts which such a course encourages is, in my opinion, one of its worst features.

I believe that in the near future our students will first be set to solve problems, each in its way a little research, and involving much simple quantitative work; they will thus be taught chemical method, or, in other words, *the art of discovery*. They will then be taken through a course of quantitative exercises with the object of making them acquainted, by direct contact with the facts, with the fundamental principles of our science, which are but too rarely appreciated at the present day. After this, they will seek to acquire proficiency in quantitative analysis and in the art of making preparations; and subsequently they will give sufficient attention to the study of physical properties to enable them to appreciate the physico-chemical methods of inquiry which are now of such importance. The study of qualitative analysis in detail will be left to the last, as being an eminently technical subject. Meanwhile, by attendance at lectures, by reading carefully chosen works of a kind altogether different from the soul-destroying text-books we now possess, and especially by the study of classical models in chemical literature, they will have acquired what is commonly spoken of as theoretical knowledge, but too often regarded by us as of secondary importance, and which it is so difficult to make Englishmen realize means a proper understanding of the subject. Students so trained—imbued from the outset, even from early school days, with the research spirit—will at all times be observant and critical, nay, even logical; dogmatic teaching will cease to have any charm for them: they will actually take deep interest in their studies—a result devoutly to be hoped for, as nothing is more galling to the teacher at the present day than the crass indifference of the average student and his refusal to give attention to anything unless it will pay in an examination. At the close of such a course the student will be thoroughly prepared to undertake original investigation, distinctly with the object of exhibiting his individuality and originality, and not, as at present, with the object of

acquiring for the first time an insight into the methods of the investigator; he will thus be spared the unpleasant discovery which the advanced student now too often makes that his early training has unfitted him, rather than prepared him, for the task of original inquiry.

Much to be feared, also, is the tendency to overestimate the value of examinations, and the great work of the future will be so to improve these that they shall have no prejudicial influence on the student's work and in no way check the development of original methods of teaching; we must fix our attention mainly on the influences to which the student is to be subjected during his career; the competent teacher will ever study his students while they are at work, and do the best for them, provided he be not rendered powerless by the trammels of an examination system which heeds "results" only and not individuals.

Finally, let me say that, while sympathizing most fully with those who advocate a complete course of study, I feel that it is very easy to demand too much—very easy to make it impossible for students to do justice to their work by imposing too many subjects. Our chief desire must always be that students shall acquire a knowledge of scientific method and the power of working independently. Certain subjects must be insisted on—for example, mathematics and drawing—if a knowledge of these be not acquired early it will never be acquired; but apart from these and a competent knowledge of the main subject, we probably may, as a rule, be satisfied with comparatively little. Those who have once learned to work and acquired a knowledge of scientific method will, of their own accord, in proportion to their intelligence, apply themselves also to the study of other subjects—as many among us have done; those who are not sufficiently intelligent to do this are not, as a rule, improved by being forced to pay attention to unpalatable studies; on the contrary, they are, more often than not, thereby hindered from acquiring a competent knowledge of some one subject which does appeal to them, and are spoiled for life in consequence.—*Reprinted from Nature.*

THE studies of Dr. R. W. Shufeldt have led him to believe that the art of taxidermy has had an evolutionary growth peculiarly its own, and that of recent years the strong tendency in the leading museums has been to group animals, and for a variety of purposes. The author is convinced that in the future museums will carry this idea still further, and that the groups will be so combined as to exhibit, besides single species, showing some of their habits and surroundings in their natural haunts, also to a large extent faunal regions, and the animal and plant life of various geographical areas. By such arrangements the eye will be enabled to take in and the mind appreciate the aspect and the biologic forms of any particular region of the United States almost at a glance.

ETHICAL RELATIONS BETWEEN MAN AND BEAST.

By Prof. E. P. EVANS.

ETHNOCENTRIC geography, which caused each petty tribe to regard itself as the center of the earth, and geocentric astronomy, which caused mankind to regard the earth as the center of the universe, are conceptions that have been gradually outgrown and generally discarded—not, however, without leaving distinct and indelible traces of themselves in human speech and conduct. But this is not the case with anthropocentric psychology and ethics, which treat man as a being essentially different and inseparably set apart from all other sentient creatures, to which he is bound by no ties of mental affinity or moral obligation. Nevertheless, all these notions spring from the same root, having their origin in man's false and overweening conceit of himself as the member of a tribe, the inhabitant of a planet, or the lord of creation.

It was upon this sort of anthropocentric assumption that teleologists used to build their arguments in proof of the existence and goodness of God as shown by the evidences of beneficent design in the world. All their reasonings in support of this doctrine were based upon the theory that the final purpose of every created thing is the promotion of human happiness. Take away this anthropocentric postulate, and the whole logical structure tumbles into a heap of unfounded and irrelevant assertions leading to lame and impotent conclusions.

Thus Bernardin de Saint-Pierre states that garlic, being a specific for maladies caused by marshy exhalations, grows in swampy places, in order that the antidote may be easily accessible to man when he becomes infected with malarious disease. Also the fruits of spring and summer, he adds, are peculiarly juicy, because man needs them for his refreshment in hot weather; on the other hand, autumn fruits, like nuts, are oily, because oil generates heat and keeps men warm in winter. It is for man's sake, too, that in lands where it seldom or never rains there is always a heavy deposition of dew. If we can show that any product or phenomenon of Nature is useful to *us*, we think we have discovered its sufficient *raison d'être*, and extol the wisdom and kindness of the Creator; but if anything is harmful to us we can not imagine why it should exist. How much intellectual acuteness and learning have been expended to reconcile the fact that the moon is visible only a very small part of the time, with the theory that it was intended to illuminate the earth in the absence of the sun, for the benefit of its inhabitants!

Gennadius, a Greek presbyter, who flourished at Constantino-

ple about the middle of the fifth century remarks in his commentary on the first chapter of Genesis, that God created the beasts of the earth and the cattle after their kind on the same day on which he created man, in order that these creatures might be there ready to serve him.

But it would be superfluous to multiply examples of the influence of this anthropocentric idea as it has worked itself out in the history of mankind. Every science has had to encounter its opposition, and it has been a stumbling-block in the way of every effort to enlarge human knowledge and to promote human happiness. It has tended to check the progress of hygienic research and sanitary reform; for if man is of such exceptional importance that his conduct or misconduct can bring down epidemics upon whole communities and vast continents as visitations of divine wrath, whoever seeks to ward off or to stay these punishments is guilty of a sacrilegious attempt to parry the blow aimed at the wicked by the arm of the Almighty, and, by thus setting himself in antagonism to God, becomes in fact an ally and adversary of the devil. Thus vaccination was denounced, not on the ground taken by its present opponents, that it is useless as a preventive of smallpox and a prolific source of other diseases, but on account of its real or supposed prophylactic effectiveness, since it impiously wrenched from the hand of the Deity one of his most fatal weapons of retribution.

To what absurdities of presumption the anthropocentric conception has paved the way is evident from the belief, once universally entertained, that the sun, moon, and stars were placed in the firmament with express reference to man, and exerted a benign or baleful influence upon his destiny from the cradle to the grave. Owen Glendower's bombastic boast—

> ". . . At my nativity
> The front of heaven was full of fiery shapes,
> Of burning cressets; and at my birth
> The frame and huge foundation of the earth
> Shaked like a coward"—

was well answered by Hotspur: "Why, so it would have done at the same season if your mother's cat had but kittened, though yourself had ne'er been born." And yet this fulsome brag of the Welsh swashbuckler was only an extravagant statement of what the captious Henry Percy and his contemporaries all held to be virtually true. Poe embodies the same sentiment in his youthful poem, Al Aaraaf, and would fain preserve this brighter world of his fancy from the contagion of human evil—

> "Lest the stars totter in the guilt of man."

Astrology and horoscopy, from which even the keen intellects of Kepler and Tycho de Brahe could not disentangle themselves, and to which the still more modern genius of Goethe paid a characteristic tribute in the story of his nativity, were only this anthropocentric conceit masquerading as science, and leaving vestiges of itself in such common words as "ill-starred" and "lunatic."

Comets were universally regarded as portents of disasters, sent expressly as warnings for the reproof and reformation of mankind; tempests and lightnings were feared as harbingers of divine wrath and instruments of punishment for human transgression. According to the Rev. Increase Mather, God took the trouble to eclipse the sun in August, 1672, merely to prognosticate the death of the President of Harvard College and of two colonial governors, all of whom "died within a twelvemonth after." This is but a single example of the wide prevalence and general acceptance of a popular superstition constantly tested and easily proved by the logical fallacy *post hoc ergo propter hoc.* Bayle, in his Divers Thoughts on Comets (*Pensées Diverses sur les Comètes*), ridicules the foolish pride and vanity of man, who imagines that "he can not die without disturbing the whole course of Nature and compelling the heavens to put themselves to fresh expense in order to light his funeral pomp."

Not only were the fruits of the earth made to grow for human sustenance, but the flowers of the field were supposed to bud and blossom, putting on their gayest attire and emitting their sweetest perfume, solely as a contribution to human happiness; and it was deemed one of the mysteries and mistakes of Nature, never too much to be puzzled over and wondered at, that these things should spring up and expend their beauty and fragrance in remote places untrodden by the foot of man. Gray expresses this feeling in the oft-quoted lines:

> "Full many a flower is born to blush unseen,
> And waste its sweetness on the desert air."

Science has finally and effectually taken this conceit out of man by showing that the flower blooms not for the purpose of giving him agreeable sensations, but for its own sake, and that it presumed to put forth sweet and beautiful blossoms long before he appeared on the earth as a rude cave-haunting and flint-chipping savage.

The color and odor of the plant are designed not so much to please man as to attract insects, which promote the process of fertilization and thus insure the preservation of the species. The gratification of man's æsthetic sense and taste for the beautiful does not enter into Nature's intentions; and although the flower may bloom unseen by any human eye, it does not on that ac-

count waste its sweetness, but fully accomplishes its mission, provided there is a bee or a bug abroad to be drawn to it. That the fragrance and variegated petals are alluring to a vagrant insect is a condition of far more importance in determining the fate of the plant than that they should be charming to man.

Plants, on the other hand, which depend upon the force of the wind for fructification, are not distinguished for beauty of color or sweetness of odor, since these qualities, however agreeable to man, would be wasted on the wind. This is an illustration of the prudent economy of Nature, which never indulges in superfluities or overburdens her products with useless attributes; but the test of utility which "great creating Nature" sets up in such cases is little flattering to man, and has no reference to his tastes and susceptibilities, but is determined solely by the serviceableness of certain qualities of the plant itself in the struggle for existence.

According to Schopenhauer, anthropocentric egoism is a fundamental and fatal defect in the psychological and ethical teachings of both Judaism and Christianity, and has been the source of untold misery to myriads of sentient and highly sensitive organisms. "These religions," he says, "have unnaturally severed man from the animal world, to which he essentially belongs, and placed him on a pinnacle apart, treating all lower creatures as mere things; whereas Brahmanism and Buddhism insist not only upon his kinship with all forms of animal life, but also upon his vital connection with all animated Nature, binding him up into intimate relationship with them by metempsychosis."

In the Hebrew cosmogony there is no continuity in the process of creation, whereby the genesis of man is in any wise connected with the genesis of the lower animals. After the Lord God, by his fiat, had produced beasts, birds, fishes, and creeping things, he ignored all this mass of protoplastic and organic material, and took an entirely new departure in the production of man, whom he formed out of the dust of the ground. Science shows him to have been originally a little higher than the ape, out of which he was gradually and painfully evolved; Scripture takes him out of his environment, severs him from his antecedents, and makes him a little lower than the angels. Upon the being thus arbitrarily created absolute dominion is conferred over every beast of the earth and every fowl of the air, which are to be to him "for meat." They are given over to his supreme and irresponsible control, without the slightest injunction of kindness or the faintest suggestion of any duties or obligations toward them.

Again, when the earth is to be renewed and replenished after the deluge, the same principles are reiterated and the same line of demarcation is drawn and even deepened. God blesses Noah and his sons, bids them "be fruitful and multiply," and then adds, as

regards the lower animals: "The fear of you and the dread of you shall be upon every beast of the earth and upon every fowl of the air, upon all that moveth upon the earth, and upon all the fishes of the sea; into your hand are they delivered. Every moving thing that liveth shall be meat for you; even as the green herb have I given you all things."

This tyrannical mandate is not mitigated by any intimation of the merciful manner in which the human autocrat should treat the creatures thus subjected to his capricious will. On the contrary, the only thing that he is positively commanded to do with reference to them is to eat them. They are to be regarded by him simply as food, having no more rights and deserving no more consideration as means of sating his appetite than a grain of corn or a blade of grass.

The practical working of this decree has been summed up by Shelley, with his wonted force and succinctness, when he says, "The supremacy of man is, like Satan's, a supremacy of pain." Burns regrets the fatal effect of the sovereignty thus conferred upon the human race in destroying the mutual sympathy and confidence which should exist between the lord of creation and the lower animals in the lines addressed To a Mouse, on turning her up in her Nest with the Plow, November, 1785:

"I'm truly sorry man's dominion
Has broken Nature's social union,
An' justifies that ill opinion
Which makes thee startle
At me, thy poor earth-born companion,
An' fellow-mortal."

In the subsequent annals of the world we have ample commentaries on this primitive code written in the blood of helpless, innocent, and confiding creatures, which, although called dumb and incapable of recording their sufferings, yet

". . . have long tradition and swift speech,
Can tell with touches and sharp-darting cries
Whole histories of timid races taught
To breathe in terror by red-handed man."

Indeed, ever since Abel's firstlings of the flock were more acceptable than Cain's bloodless offerings of the fruits of the fields, priests have performed the functions of butchers, converting sacred shrines into shambles in their endeavors to pander to the gross appetites of cruel and carnivorous gods. Cain's offering was rejected, says Dr. Kitto, because "he declined to enter into the sacrificial institution." In other words, he would not shed the blood of beasts to gratify the Lord—a refusal which we

can not but regard as exceedingly commendable in Adam's first-born.

"I do not remember," observed Mrs. Jameson, "ever to have heard the kind and just treatment of animals enforced on Christian principles or made the subject of a sermon." George Herbert was a man of gentle spirit and ready hand for the relief of all forms of human distress, and in his book entitled A Priest to the Temple, or the Country Parson, lays down rules and precepts for the guidance of the clergyman in all relations of life, even to the minutest circumstances and remotest contingencies incident to parochial care. But this tender-hearted man does not deem it necessary for the parson to take the slightest interest in animals, and does not utter a word of counsel as to the manner in which his parishioners should be taught their duties toward the creatures so wholly dependent upon them. Indeed, no treatise on pastoral theology ever touches this topic, nor is it ever made the theme of a discourse from the pulpit, or of systematic instruction in the Sunday school.

Neither the synagogue nor the church, neither sanhedrin nor ecclesiastical council, has ever regarded this subject as falling within its scope, and sought to inculcate as a dogma or to enforce by decree a proper consideration for the rights of the lower animals. One of the chief objections urged by Celsus more than seventeen centuries ago against Christianity was that it "considers everything as having been created solely for man." This stricture is indorsed by Dr. Thomas Arnold, of Rugby, who also animadverts on the evils growing out of the anthropocentric character of Christianity as a scheme of redemption and a system of theodicy. "It would seem," he says, "as if the primitive Christian, by laying so much stress upon a future life in contradistinction to this life, and placing the lower creatures out of the pale of hope, placed them at the same time out of the pale of sympathy, and thus laid the foundation for this utter disregard of animals in the light of our fellow-creatures. The definition of virtue among the early Christians was the same as Paley's—that it was good performed for the sake of insuring eternal happiness—which of course excluded all the so-called brute creatures. Kind, loving, submissive, conscientious, much-enduring, we know them to be; but because we deprive them of all stake in the future, because they have no selfish, calculated aim, these are not virtues; yet if we say 'a vicious horse,' why not say 'a virtuous horse'?"

We are ready enough, adds Dr. Arnold, to endow animals with our bad moral qualities, but grudge them the possession of our good ones. The Germans, whose natural and hereditary sympathy with the brute creation is stronger than that of any other West-

ern people, speak of horses as "*fromm*," pious, not in the religious, but in the primary and proper sense of the word, meaning thereby kind and docile. The English "gentle" and the French "*gentil*," which are used in the same connection, refer to good conduct as the result of fine breeding.

Archdeacon Paley's definition of virtue, to which Dr. Arnold adverts, is essentially anthropocentric and intensely egoistic. "Virtue," he says, "is the doing good to mankind in obedience to the will of God, for the sake of everlasting happiness." In order to be virtuous, according to this extremely narrow and wholly inadequate conception of virtue, we must, in the first place, do good to mankind, our conduct toward the brute creation not being taken into the account; secondly, our action must be in obedience to the will of God, thus ruling out all generous impulses originating in the spontaneous desire to do good; thirdly, we must have an eye single to our own supreme personal advantage—in other words, our conduct must be utterly selfish, spring not merely from momentary pleasure or temporary profit, but from far-seeing calculations of the effect it may have in securing our eternal happiness. Thus the virtuous man becomes the incarnation of the intensest self-love and self-seeking, and virtue the synonym of excessive venality. From a moral point of view, there is no greater merit in "otherworldliness" than in worldliness, and no reason why the endeavor to attain personal happiness in a future life should differ in quality from the effort to make everything minister to our personal happiness in the present life.

"The whole subject of the brute creation," says Dr. Arnold, "is to me one of such painful mystery that I dare not approach it." The mental distress experienced in such cases arises from the fact that the subject is approached from the wrong side and surveyed from a false point of view. Traditional theology and anthropocentric ethics are brought into conflict with the better impulses of a broad and generous nature and the sharp antagonism could hardly fail to be a source of perplexity and pain. "Charity," says Lord Bacon, "will hardly water the ground, where it must first fill a pool"; and of all pools the hardest to fill is that which is dug in the dry, gravelly soil of human egotism.

Theocritus, the father of Greek idyllic poetry, represents Hercules as exclaiming, after he had slain the Nemean lion, "Hades received a monster soul"; and he saw nothing incongruous in the spirit of the dead beast joining the company of the departed spirits of men in the lower world. Sydney Smith says, in speaking of the soul of the brute, "To this soul some have impiously allowed immortality." Why such a belief should be deemed impious it is difficult to discover. The question which the psychol-

ogist has to consider is not whether the doctrine is impious, but whether it is true. No scientific opinion has ever been advanced that has not seemed impious to some minds, and been denounced and persecuted as such by ecclesiastical authorities.

Bishop Butler, on the contrary, in his work on The Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature, declares that "we can not find anything throughout the whole analogy of Nature to afford us even the slightest presumption that animals ever lose their living powers." He admits that his argument in support of the doctrine of a future life proves the immortality of brutes as well as that of man, and thus recognizes their spiritual kinship.

An eminent Scotch physician and anatomist, Dr. John Barclay, in his Inquiry into the Opinions, Ancient and Modern, concerning Life and Organization (1825), urges the probable immortality of the lower animals, which, he thinks, are "reserved, as forming many of the accustomed links in the chain of being, and by preserving the chain entire, contribute in the future state, as they do here, to the general beauty and variety of the universe, a source not only of sublime but of perpetual delight." The author seems to infer the continued existence of the brute creation from the fact that it forms an essential part of universal being, and that its total disappearance would mar the perfection of the next world, which should be more perfect than this world. He assumes, however, that the lower animals are endowed with immortality, not so much from psychological necessity or for their own sake as sentient and intelligent creatures, as for man's sake, in order that their presence may minister to his pleasure by forming an attractive feature in the heavenly landscape. It is, therefore, solely from anthropocentric considerations that they are granted this lease of eternal life; just as "the poor Indian" is represented by the poet as looking forward to the possession of happy hunting fields after death, where he may follow with keener enjoyment his favorite pursuit, and "his faithful dog shall bear him company."

More than fifty years ago Henry Hallam made the following observations, which are remarkable as an anticipation of the ethical corollary to the doctrine of evolution: "Few at present, who believe in the immortality of the human soul, would deny the same to the elephant; but it must be owned that the discoveries of zoölogy have pushed this to consequences which some might not readily adopt. The spiritual being of a sponge revolts a little our prejudices; yet there is no resting place, and we must admit this or be content to sink ourselves into a mass of medullary fiber. Brutes have been as slowly emancipated in philosophy as some classes of mankind have been in civil polity; their

souls, we see, were almost universally disputed to them at the end of the seventeenth century, even by those who did not absolutely bring them down to machinery. Even within the recollection of many, it was common to deny them any kind of reasoning faculty, and to solve their most sagacious actions by the vague word instinct. We have come in late years to think better of our humble companions; and, as usual in similar cases, the preponderant bias seems rather too much of a leveling character." During the half century that has elapsed since these words were written, not only has zoölogy made still greater progress in the direction indicated, but a new science of zoöpsychology has sprung up, in which the mental traits and moral qualities of the lower animals have been, not merely recorded as curious and comical anecdotes, but systematically investigated and philosophically explained. In consequence of this radical change of view, human society in general has become more philozoic, not upon religious or sentimental but upon strictly scientific grounds, and developed a sympathy and solidarity with the animal world, having its sources less in the tender and transitory emotions of the heart than in the profound and permanent convictions of the mind.

In an essay published a few years ago in The Dublin Review (October, 1887, p. 418), the Right Rev. John Cuthbert Hedley, Bishop of Newport and Menevia, asserts that animals have no rights, because they are not rational creatures and do not exist for their own sake. "The brute creation have only one purpose, and that is to minister to man, or to man's temporary abode." This is the doctrine set forth more than six centuries ago by Thomas Aquinas, and recently expounded by Dr. Leopold Schutz, professor in the theological seminary at Treves, in an elaborate work entitled The So-called Understanding of Animals or Animal Instinct. This writer treats the theory of the irrationality of brutes as a dogma of the Church, denouncing all who hold that the mental difference between man and beast is one of degree, and not of kind, as "enemies of the Christian faith"; whereas those who cling to the old notion of instinctive or automatic action in explaining the phenomena of animal intelligence are extolled as "champions of pure truth."

If it was the Creator's intention that the lower animals should minister to man, the divine plan has proved to be a failure, since the number of animals which, after centuries of effort, he has succeeded in bringing more or less under his dominion is extremely small. Millions of living creatures fly in the air, crawl on the earth, dwell in the waters, and roam the fields and the forests, over which he has no control whatever. Not one in twenty thousand is fit for food, and of those which are edible he does not actually eat more than one in ten thousand. In explana-

tion of this lack of effectiveness in the enforcement of a divine decree, it has been asserted that man lost his dominion over the lower world to a great extent when he lost dominion over himself; but this view is wholly untenable even from a biblical standpoint, inasmuch as the promise of universal sovereignty was renewed after the deluge and expressed in even stronger terms than before the fall.

Dugald Stewart admits "a certain latitude of action, which enables the brutes to accommodate themselves in some measure to their accidental situations." In this arrangement he sees a design or purpose of "rendering them, in consequence of this power of accommodation, incomparably more serviceable to our race than they would have been if altogether subjected, like mere matter, to the influence of regular and assignable causes." Of the value of this power of adaptation to the animal itself in the struggle for existence the Scotch philosopher had no conception.

In the great majority of treatises on moral science, especially in such as base their teachings on distinctively Christian tenets, there is seldom any allusion to man's duty toward animals. Dr. Wayland, who has perhaps the most to say on this point, sums up his remarks in a note apologetically appended to the body of his work. He denies them the possession of "any moral faculty," and declares that in all cases "our right is paramount and must extinguish theirs." We are to treat them kindly, feed and shelter them adequately, and "kill them with the least possible pain." To inflict suffering upon them for our amusement is wrong, since it tends to harden men and render them brutal and ferocious in temper.

Dr. Hickok takes a similar view and broadly asserts that "neither animate nor inanimate Nature has any rights," and that man is not bound to it "by any duties for its own sake. . . . In the light of his own worthiness as end, . . . he is not permitted to mar the face of Nature, nor wantonly and uselessly to injure any of her products." Maliciously breaking a crystal, defacing a gem, girdling a tree, crushing a flower, painting flaming advertisements on rocks, and worrying and torturing animals are thus placed in the same category as acts tending to degrade man ethically and æsthetically, rendering him coarse and rude, and making him not only a very disagreeable associate, but also, in the long run, "an unsafe member of civil society." These things are considered right or wrong solely from the standpoint of their influence upon human elevation or degradation. "Nature possesses no product too sacred for man. All Nature is for man, not man for it."

Man is as truly a part and product of Nature as any other animal, and this attempt to set him up on an isolated point outside of it is philosophically false and morally pernicious. It makes

fundamental to ethics a principle which once prevailed universally in politics and still survives in the legal fiction that the king can do no wrong. Louis XIV of France firmly believed himself to be the rightful and absolute owner of the lives and property of his subjects. He held that his rights as monarch were paramount and extinguished theirs, that they possessed nothing too sacred for him, and the leading moralists and statists of his day confirmed him in this extravagant opinion of his royal prerogatives. All the outrages which the mad Czar, Ivan the Terrible, perpetrated on the inhabitants of Novgorod and Moscow, man has felt and for the most part still feels himself justified in inflicting on domestic animals and beasts of venery.

It is only within the last century that legislators have begun to recognize the claims of brutes to just treatment and to enact laws for their protection. Torturing a beast, if punished at all, was treated solely as an offense against property, like breaking a window, barking a tree, or committing any other act known in Scotch law as "malicious mischief." It was regarded, not as a wrong done to the suffering animal, but as an injury done to its owner, which could be made good by the payment of money. Not until a little more than a hundred years ago was such an act changed from a civil into a criminal offense, for which a simple fine was not deemed a sufficient reparation. It was thus placed in the category of crimes which, like arson, burglary, and murder, are wrongs against society, for which no pecuniary restitution or compensation can make adequate atonement.

Even this legislative reform is by no means universal. The criminal code of the German Empire still punishes with a fine of not more than fifty thalers any person "who publicly, or in such wise as to excite scandal, maliciously tortures or barbarously maltreats animals." This sort of cruelty is classified with drawing plans of fortresses, using official stamps and seals, and putting royal or princely coats of arms on signs without permission, making noises, which disturb the public peace, and playing games of hazard on the streets or market places. The man is punished, not because he puts the animal to pain, but because his conduct is offensive to his fellow-men and wounds their sensibilities. The law sets no limit to his cruelty, provided he may practice it in private.

Again, in all enactments regulating the transportation of live stock our legislation is still exceedingly defective. The great majority of people have no conception of the unnecessary and almost incredible suffering inflicted by man upon the lower animals in merely conveying them from one place to another in order to meet the demands of the market. It is well known that German shippers of sheep to England often lose one third of their consignment by suffocation, owing to overcrowding and imperfect ventilation.

Beasts are still made to endure all the horrors to which slavers were once wont to subject their cargoes of human chattels in stifling holds on the notorious "middle passage."

The late Henry Bergh states that the loss on cattle by "shrinkage" in transporting them from the Western to the Eastern portion of the United States is from ten to fifteen per cent. The average shrinkage of an ox is one hundred and twenty pounds, and that of a sheep or hog from fifteen to twenty pounds; and the annual loss in money arising from this cause is estimated at more than forty million dollars. The amount of animal suffering which these statistics imply is fearful to contemplate. Here and there a solitary voice is heard in our legislative halls protesting against the horrors of this traffic, but so powerful is the lobby influence of wealthy corporations that no law can be passed to prevent them. Not a word ever falls from the pulpit in rebuke of such barbarity; meanwhile the railroad magnates pay liberal pew rents out of the profits, and listen with complacency one day in the week to denunciations of Jeroboam's idolatry and the wicked deeds of Ahab and Ahaziah, as recorded in the chronicles of the kings of Israel.

The horse, one of the noblest and most sensitive of domestic animals, is put to all kinds of torture by docking, pricking, clipping, peppering, and the use of bearing reins solely to gratify human vanity. As a reward for severe and faithful toil he is often fed with unwholesome and insufficient fodder on the economical principle announced by the manager of a New York tramway that "horses are cheaper than oats." It is an actual fact, verified by Henry Bergh, that the horses of this large corporation were fed on a mixture of meal, gypsum, and marble dust, until the Society for the Prevention of Cruelty to Animals interfered and finally succeeded in putting a stop to the practice.

The Americans, as a people, are notorious for the recklessness with which they squander the products of Nature, of which their country is so exceedingly prolific. This extravagance extends to all departments of public, social, and domestic life. No land less rich in material resources could have borne for any length of time the wretched mismanagement of its finances to which the United States has been subjected ever since and even before the close of the civil war. There is not a government in Europe that would not have been broken down and rendered bankrupt by the tremendous and wholly unnecessary strain put upon it by crass ignorance of the most elementary principles of finance and demagogical tampering with the public credit. The same wasteful spirit involves also, as we have seen, immense suffering to animals on the part of soulless and unscrupulous corporations, in which intense greed of gain is not mitigated by the influence of individual kind-

ness, and by which horses are treated as mere machines, to be worked to their utmost capacity at the smallest expense, and neat cattle as so much butcher's meat to be brought to market in the quickest and cheapest manner.

Erasmus Darwin, in his Phytologia, or the Philosophy of Agriculture and Gardening (London, 1800), endeavors to vindicate the goodness of God in permitting the destruction of the lower by the higher animals on the ground that "more pleasurable sensation exists in the world, as the organic matter is taken from a state of less irritability and less sensibility and converted into a greater." By this arrangement, he thinks, the supreme sum of possible happiness is secured to sentient beings. Thus it may be disagreeable for the mouse to be caught and converted into the flesh of the cat, for the lamb to be devoured by the wolf, for the toad to be swallowed by the serpent, and for sheep, swine, and kine to be served up as roasts and ragouts for man; but in all such cases, he argues, the pain inflicted is far less than the amount of pleasure ultimately procured. But how is it when a finely organized human being, with infinite capabilities of happiness in its highest forms, is suddenly transmuted into the bodily substance of a boa constrictor or a tiger? No one will seriously assert that the drosera, *Dionœa muscipula*, and other insectivorous and carnivorous plants are organisms superior in sensitiveness to those which they devour, or that this transformation of animal into vegetable structure increases the sum of pleasurable sensation in the world. The doctrine of evolution, which regards these antagonisms as mere episodes in the universal struggle for existence, has forever set aside this sort of theodicy and put an end to all teleological attempts to infer from the nature and operations of creation the moral character of the Creator.

SEEKING for a higher meteorological station among the mountains of Peru than that of Mount Chanchani, Prof. Bailey, of the Harvard College Observatory, has established a station upon the top of the volcano El Misti, at an elevation of nineteen thousand two hundred feet. A path has been constructed by which mules have been led to the summit, and beside the meteorological shelter a wooden hut has been built there. A survey of the crater has been made, and a stone hut has been erected on the side of the mountain at a height of fifteen thousand feet. The temperature, pressure, moisture, and velocity and direction of the wind are recorded at the summit station by self-registering instruments. The sheets are changed at intervals, thus giving a record of atmospheric conditions at a height hitherto unattempted. The use of beasts of burden at these heights offers an opportunity in the future of carrying instruments and conducting experiments at altitudes heretofore regarded as inaccessible for these purposes. The mountain, as seen from every direction, is an isolated sharp peak. It is, therefore, especially suited for the study of the upper atmosphere.

THE WORK OF DUST.

By Dr. P. LENARD.

WHEN a beam of sunlight enters a darkened room through a hole in the window shutter, it can be seen along its whole course. The light is reflected to every side, and made to reach the eye by the dust in the air of the room. We do not see the sunbeam itself, but the dust which is illuminated by it; and individual bodies can be perceived on a closer inspection floating in the beam. The dust may be much more plainly observed in still air, as it settles on objects. It is extremely slow in falling to the ground, although it consists of matter which in larger masses falls very speedily. This we can test by collecting dust and compressing it into a ball. In this process of compression a very large part of the exposed surface which the particles presented to the air is caused to disappear; and it was by means of this great extent of surface that the air bore enough upon the particles to support them against falling. The finer the dust the more extended is its surface in proportion to its mass, and the more it is delayed in falling through the air. It may seem useless to speak of the part played by this dust in Nature; for what noticeable effect can this insignificant stuff bring about? We have, however, as can be shown, no right to regard it as a little thing.

Dust has a very large share in nearly all the phenomena of the earth's atmosphere. It is what makes the clear sky appear blue; and when we look up into the sky we see the dust in the atmosphere illuminated by the sun. There is nothing else before us that can permit the light to reach the eye. Light goes invisible, straight through all gases, whatever their chemical composition. The dust catches it, reflects it in every direction, and so causes the whole atmosphere to appear clear, in the same way that it makes the sunbeam visible in the darkened room. Without dust there would be no blue firmament. The sky would be as dark as or darker than we see it in the finest moonless nights. The glowing disk of the sun would stand immediately upon this dark background, and the same sharp contrast would prevail upon the illuminated surface of the earth—blinding light, where the sun's rays fall, and deep black shadows where they do not. Only the light of the moon and the stars, which would remain visible in the daytime, would be able to temper this contrast in a slight degree. The illumination of the earth's surface would be like that we see with the telescope on the lunar landscapes; for the moon has no atmospheric envelope that can hold floating dust. We then owe to dust the even moderately tempered day-

light, adapted now to our eyes; and it is that which contributes much to the beauty of our landscape scenery.

But if dust makes the sky appear clear, why is the color of the sky blue? Why does dust, of the different constituents of white sunlight, reflect the blue rather than the green, yellow, and red? This fact is connected with the size of the dust particles. Only the finest dust settles so slowly that it can be spread everywhere by means of the air currents, and can be found constantly in all strata of the atmosphere; and special importance can be ascribed only to these finest particles. The coarse parts soon fall to the ground. Let us consider the fine mechanism of light, the extremely short ether waves which determine its existence. These waves, although they are of even less than microscopic size, are not all equally long. The shortest are those that give blue light, while all the other colors are produced by longer waves. The fine atmospheric dust contains many particles which are large enough to reflect the short blue ether waves, fewer that can reflect green and yellow, and still fewer large enough to reflect the long red waves. The red light, therefore, goes on almost without hindrance, while the blue is more liable to be diverted, and thus to reach the eye. A similar phenomenon may be observed on a larger scale on water which is roughened with waves of different lengths, and on which pieces of wood are floating. The pieces of wood stand in the same relation to the water waves as the dust particles to the ether waves. The great long waves pass the blocks undisturbed, only rocking up and down; while the finer ripples of the water are turned back, as if the blocks were firm walls.

The finest dust thus appears blue. Look at the smoke that rises from the glowing end of a cigar. It appears on a clear day, especially in the presence of much blue light, of the most beautiful sky blue. But that part of the smoke that is drawn through the cigar, and is seen at the other end, is composed of coarser particles, which are large enough to reflect the longest ether waves, including all the constituents of white light. It therefore appears whitish. The same difference is found between the dust in the country and that in the town. There is much coarse dust in large towns, when the sky over them is often gray, while only the finest blue dust is carried up in the country. The dust is also variously assorted at different heights above the surface of the earth. The coarser dust will be found at the lower levels, where it is produced. On mountains we have most of the dust beneath us, while the rarefied air can sustain only the finest floating particles. Hence the sky on high mountains is clear and deep blue, even almost black, as if it were without dust. Only when we look at the lower strata, toward the horizon, does the color pass into gray.

Why is the sky in Italy and the tropics of a so much deeper blue than that of western Europe? Is the dust there finer? It is really so; not that a finer quality of dust is produced there, but because in the moist climate of the North Sea countries the dust can not float long in the air without being charged with water and made coarser, while in warmer countries water exists in the air as vapor, and does not become condensed as a liquid on the dust. Only when it is carried by the air currents into the higher strata and is cooled there, does it thicken into clouds? With this we come to the most important function of dust in our atmosphere—the part which it has in the function of rain by reason of vapors condensing upon it. It can be affirmed with certainty that all the water which the sun causes to evaporate on the surface of the sea and on the land is condensed again on dust, and that no raindrop falls unless it had a particle of dust as its primary nucleus.

When we speak of "vapor" we always mean water in the gaseous condition, transparent and invisible, like all other gases but cloudy steam, such as is seen escaping from the boiler of a locomotive. The latter, like the clouds and fogs, is liquid water split up into innumerable fine drops. If the walls of a steam-boiler were of glass, we should be able to see clearly through the part of it occupied by steam. Then we have water in the gaseous form. But when the steam escapes from it into much colder air, it is condensed into liquid drops. The process is precisely the same when the vapor which the sun has drawn up in the lower warm strata of the atmosphere is cooled on rising, and forms clouds. It is usually said that the upper atmospheric strata are colder than the lower, because they permit a perfect passage of the solar rays through them, and are therefore not warmed, while the rays, on the other hand, warm the surface of the earth, and that warms the air. This is true, but it does not explain why the upper strata of the air do not become warmed in the course of time. The supposition of a cooling of these strata by space does not afford a sufficient cause, for a body which, like the air, stores up little heat, likewise by a fixed law sends little out. Were the atmosphere perfectly still it would, in fact, be warmed all through from the earth's surface. But it is in constant motion, and the heat is consequently very unevenly distributed through it. When a column of air rises into the heights from the earth's surface, it expands greatly, for the pressure to which it is subjected is much less in the higher regions than below; and whenever a gas expands it becomes colder. A quantity of heat is withdrawn from it corresponding with the force which it spends in expanding in pushing itself into the surrounding region. Ascending air, therefore, becomes cooler, descending air warmer. Thus the fact is ex-

plained that by reason of the continuous motions in the atmosphere the equality of temperature, which would exist if all the strata were equally warmed, never can come to pass.

When the rising columns of air contain a sufficient quantity of vapor, it will at a certain height be condensed into drops and form clouds. We say that the cooling is the cause of the condensation. But it is now maintained and proved by experiment that cooling alone is not adequate to do this, and that condensation takes place only on the surface of some solid or liquid body; not in the free, pure air, but on the surface of the dust particles scattered through it. Every drop of a steam-jet or a cloud is a particle of dust covered with water. The experimental proof of this is easily made. We fill a large flask with dustless air by pressing ordinary air through wadding and conducting it into the flask till all the air originally therein has been replaced with filtered air. The wadding holds back all the dust particles. We then let a jet of steam from a boiler into the dustless air of the flask. It remains invisible. Not a sign of the usual cloudy appearance is perceptible. All that we observe is that the inner walls of the flask begin to trickle; the steam is condensed only on them, for there is no other fixed surface. If, now, some ordinary dusty air is blown into the flask, it at once appears to be filled with a thick, rolling cloud. The cloud is composed of as many drops as dust particles have been admitted. If only a little dust is admitted, all the vapor is precipitated upon it, and so loads it with water in a short time that it sinks in heavy drops to the ground. It is raining in our flask. It will soon become clear, and the vapor will be invisible as before.

Without dust there would be no condensation of water in the air—no fog, no clouds, no rain, no snow, no showers. The only condensing surface would be the surface of the earth itself. Thus the trees and plants, and the walls of houses, would begin to trickle whenever cooling began in the air. In winter all would be covered with a thick, icy crust. All the water which we are accustomed to see falling in rain-pours or in snow would become visible in this way. We should at once feel on going out of doors that our clothes were becoming wet through. Umbrellas would be useless. The air, saturated with vapor, would penetrate the interior of houses and deposit its water on everything in them. In short, it is hard to conceive how different everything would be, if dust did not offer its immeasurable extent of surface everywhere to the air. To this we owe it that the condensation of water is diverted from the surface of the earth to the higher, cooler atmospheric strata.

Since the importance of dust in meteorological phenomena has been recognized, experiments have been made in counting the

particles in the air. Pasteur had already begun an investigation in that direction. He filtered a measured quantity of air through gun cotton, which retained all the particles of dust. This was then dissolved in a mixture of ether and alcohol, and the solution was dried to a sheet of clear and transparent collodion, in which the particles could be observed under the microscope and counted. The chief purpose of this experiment was to secure the yeast germs in the air. A better process for counting dust is based on our experiment with the dustless flask, and, like that, was devised by Mr. John Aitken, in Edinburgh. A measured quantity of the air to be tested—say, about a hundredth part of the contents of the flask—is let into it. The counting is facilitated by this dilution. The air in the flask has been already saturated with moisture, while it has been compressed by forcing in some dustless air. A faucet is suddenly opened, when the air expands, is cooled by the expansion, and the vapor settles on all the dust particles, weights them, and causes them soon to sink to the bottom. The bottom of the flask is made of a bright silver or a glass plate, on which a network of square millimetres is scratched. On this network as many drops of water fall as there were dust particles, and they can be counted with a lens. The number of dust particles in a cubic centimetre of air is—in London, for example, even at the borders of the city, and when the wind is blowing toward it from without—nearly a quarter of a million. About the same number are found in the air of Paris, and half as many at the top of the Eiffel Tower. The air of the Alps is very much purer. On the top of the Rhigi there were about two hundred particles to a cubic centimetre, and a few less after a fall of rain. In the relatively pure air of mountain tops the breath is not condensed into a visible cloud, even in cold weather. As we descend and approach villages whose chimney tops are smoking, the accustomed breath clouds appear again. But a steam jet is visible everywhere, for perfectly dustless air is not found anywhere.

Dust is usually spoken of as something peculiar to the earth. It is, however, present in space. Our solar system has its dust atmosphere, although it is extremely thinly sown. Besides the large blocks of matter, the meteoric stones, meteoric dust is incessantly falling from space upon the earth. Attention was first directed to this fact in 1869, when a meteorite fell at Upsala, and a shower of black dust at the same time. The dust was collected, and exhibited the same composition as the meteorite—carbon and iron. Since then several falls of cosmic dust of identical composition have been observed where no meteorites were seen. The recent advance of celestial photography has furnished images of externally faint clouds floating in space. These clouds do not

participate, like earthly things, in the revolution around the axis, but remain fixed among the stars through the night. When near enough to the earth they can be seen with the naked eye as luminous clouds, long after sunset, till they are covered by the earth's shadow.

The presence of dust in planetary space is not strange. In the midst of it is the sun, the surface of which is like an immense volcano. We can only ask how the dust clouds of the solar eruptions can be diffused in space, against the attraction of the sun. An answer to this question is afforded by the electro-magnetic theory of light, and we can rely upon it because the theory has been confirmed by experimental demonstration. It teaches that the lighter undulations of the ether are of an electrical nature, and that consequently light exerts a pressure on all bodies upon which it falls. The illuminated body is repelled from the source of the light. We have also learned the amount of this pressure. It is so small that the scale of the most sensitive balance is not moved by it when the clear sunshine falls upon it from above; but it increases with the extent of the surface exposed to the light. Let us now suppose a body isolated anywhere in planetary space. It is subject to general attraction and is drawn toward the sun. The force with which the light of the sun repels it is slight as compared with the attraction. Let us imagine this body divided into smaller and smaller fragments. It then offers the sun a larger and larger surface, and in the same measure the force increases with which all the parts collectively are repelled from the sun. The amount of attractive force is, on the other hand, not changed, for it depends upon the mass of the body, and that has not been altered. It will be seen that the division of the body has only to be carried far enough for the repulsive force ultimately to exceed the attraction. Calculation shows that this is already the case when the body is changed into a dust cloud of not excessive fineness. Such a dust cloud will be no longer attracted toward the sun, but will be driven away by its light. It will be like the comets' tails, which consist chiefly of dust, radiate from the nuclei, and are always turned away from the sun.

Thus, even insignificant, common dust has its considerable part in the processes of Nature; and there is as much of the wonderful and mysterious concealed in it as in anything else.—*Translated for The Popular Science Monthly from Die Gartenlaube.*

In the interest of good roads, the watering carts of Malden, Mass., are furnished with broad tires, of which the forward pair are set nearer together than those of the rear, so that the track of the former is just inside of that of the latter. The carts thus serve as rollers as well as for their primary purpose.

ARCTIC TEMPERATURES AND EXPLORATION.

By STUART JENKINS.

AT the recent annual meeting of the Association of Ontario Land Surveyors, held in the city of Toronto, the statement was made that, if the Canadian Government determined to run a meridian to the north pole, Canadian surveyors would carry the work through. As a proof of the faith that is in them, they have appointed a committee to consider and report upon the matter.

The assertion is not as wild as it may seem, and I think it will prove interesting to the public to show what Canadian surveyors have already done, and compare their methods and experience with those of arctic explorers.

The extreme cold of the arctic regions is generally looked upon as the principal bar to exploration in that direction, notwithstanding the fact that men have endured its rigors for years without injury. Take some of the cases on record. In 1743 four seamen went ashore on the island of Spitzbergen from a Russian vessel. A heavy storm drove the ship away before they could rejoin her, and they were left with nothing but a gun and enough ammunition to kill twelve deer. That was their entire outfit, yet they managed to live and keep their health for six years, when three of them were rescued, the fourth having died. No properly organized polar expedition would have to submit to the hardships which they must have endured.

In 1819–'20 Parry wintered on Melville Island in latitude 74° 26′. The greatest cold was experienced in February, when the thermometer fell to −55° F., and for fifteen hours was not above −54° F. The expedition was absent eighteen months, and out of two ships' crews only one man died—of a disease in no way referable to the hardships of the voyage.

Between 1853 and 1855 Dr. Kane passed two winters in Smith's Sound in latitude 78½°, and he records the mean temperature of the three summer months as +33° F., and of the nine winter months as −16·8° F. As to the possibility of traveling under the conditions existing in these high latitudes, it may be considered as established by the experience of McClintock, who in 1851 reached one of the western points of Melville Island, distant from his winter quarters three hundred and sixty miles in a direct line, a journey which required eighty days going and returning for its accomplishment. Among the things said to have been experienced by arctic explorers three may be mentioned: 1. That men issuing suddenly from their shelter into a temperature of −60° F. fell senseless. 2. That a man rushing out bare-handed

to extinguish a fire, when the thermometer stood a little below —50° F., had his fingers immediately frozen, and as it was found impossible to restore the circulation they were amputated. 3. That when it was extremely cold it was almost impossible to make the wood burn. I will come to these later.

Now for the experience of a Canadian surveyor. It was my privilege to be connected as instrument-man with a survey party which went out to the Canadian Northwest under the command of Mr. G. B. Abrey, D. L. S. (now engineer of Toronto Junction). The party consisted of fourteen men all told, and was out under canvas for twelve months, from June, 1882, to June, 1883. We were running standard parallels, and moved camp every day. This necessitated the employment of fourteen horses, two buck-boards, and twelve carts, the wheeled vehicles being replaced in winter by the same number of toboggans. Winter commenced on the 1st of November, when snow fell to the depth of two feet and remained. We then left the plains south of Battleford and made our way to Fort Pitt, near which our winter work started. Our outfit consisted of four ten-ounce duck tents, in three of which were small sheet-iron box stoves, and in the fourth, the cook's tent, a sheet-iron cook stove. Our winter food was composed of pork, beans, dried apples, and bread, with tea and sugar; to which may be added eight hundred pounds of fresh beef, and the flesh of one elk or wapiti and one jumping deer. When we could we shot prairie chickens, but this was not very often.

For clothing I wore woolen underclothing, such as I now wear in the city of Toronto, a flannel shirt, and over these caribou breeches with long woolen stockings drawn over them, a chamois-leather vest, and a small single-breasted tweed coat such as is worn in the city before overcoats become necessary in the fall. My feet were clothed with duffle and moccasins, and my head with a double, knitted, Hudson Bay tuque, which can be pulled right down over the ears. A pair of common woolen mits completed my outfit. At no time during the winter did I wear either overcoat or muffler. Indeed, neither the one nor the other was to be found in the camp. Mr. Abrey's dress was nearly the counterpart of mine, and the men wore woolen clothing altogether.

At night Mr. Abrey and I used two pairs of Hudson Bay blankets and two buffalo skins each. The blankets we sewed up into bags, and put one buffalo skin beneath and one over us. We slept on folding stretchers, which was, of course, not as warm as sleeping on the ground. Mr. Abrey, being slightly bald, wore a woolen nightcap, but I never covered my head the winter through. The men's sleeping outfits consisted of blankets only.

Our firewood was dry poplar sticks from one to two inches through. This makes a good hot fire, and *the colder the day the*

better it burns—that is our experience. But by no means can you make a fire of it burn more than half an hour without replenishing. In consequence of this, no attempt was made to keep fires burning at night. An hour after we were in bed the temperature inside the tent was the same as that outside. At no time was the temperature inside the tent raised high enough to thaw out the ground, which would only have given rise to wet feet without adding to our comfort.

A regular record of temperature was kept during the winter. Our thermometer was a standard spirit one graduated to −62° F., and had been tested at the Toronto Observatory. The record is on file in the Dominion Crown Lands Office. From the 1st of November the temperature fell in a series of remarkably regular jumps—that is, there would be three days of cold, then a few days of slightly higher temperature, then another three days of cold, and so on, each drop being colder than the last. This went on with unbroken regularity until the third week in January, when it began to rise again in the same way and with equal steadiness.

On Christmas day the weather was beautiful, still and cloudless, and the thermometer stood just at zero. I spent the day in making a pair of snowshoe frames, out of white birch, which was plentiful round the camp, my tools being an axe and an Indian crooked knife, which is nothing but a one-handed draw knife, shaped much like a farrier's knife. I worked all day with the door of the tent wide open, in my shirt sleeves, and barehanded; and from 9 A. M. to 3 P. M. there was no fire in the stove. I slipped on my coat at noon when I was eating my dinner, but took it off again immediately after. The men spent most of the day lounging about the camp in their shirt sleeves, smoking and skylarking.

The second week in January we received word that Mrs. Abrey was in Battleford waiting to join us in camp. She had come from Toronto and had traveled across the open country in the mail sleigh from Qu'appelle to Battleford *via* Duck Lake and Carleton. Mr. Abrey immediately left with two horses and carioles (i. e., toboggans with raised sides of rawhide), and one half-breed. He carried no tent. The distance to Battleford from our camp was over a hundred miles, through an open country, with here and there clumps of small poplar and birch.

I went on with the line, and the third day after Mr. Abrey left us reached the shore of Frog Lake, a few years later the scene of a horrible massacre. The next morning the cook came bustling in with the breakfast, his shirt sleeves as usual rolled up above his elbows.

"The bottom's dropped out of the thermometer," he said with a laugh.

I hurried outside, and, sure enough, the spirit had deserted the tube, and lay inclosed in the bulb—that is, it was lower than −62° F. It was startling, but there was no getting round the fact. The news spread through the camp, and the men came crowding round to see the unusual phenomenon. One man ventured the opinion that we had got to the north pole by mistake, but they looked upon it more as a joke than anything else, and were perfectly satisfied, because it meant a holiday. Mr. Abrey had made the rule that when the thermometer went below −30° F., we would not go on the line. We afterward came to the conclusion that there was nothing to prevent our working at much lower temperatures, but the rule once established it was impossible to alter it without creating discontent among the men. I went out that day two miles from camp on snowshoes, just to see how it would go, and, although it was cold at starting, I was warm enough before I got back.

The next night the thermometer went down to −58° F., and the third night to −61° F. Now, according to all precedent, we should have spent those three nights cowering with quaking hearts over the stoves, and using up the cook's fat to make the fires burn. As a matter of fact we went to bed as usual and slept without any fires at all. Not only that, but we suffered no discomfort. The only unpleasant thing about it was turning out of one's blankets in the morning to light the fire, and that I admit *was* cold, but still nothing that a strong man could not stand with equanimity.

But what will be thought when I state that during those three days of extreme cold Mr. and Mrs. Abrey were on their way from Battleford to Fort Pitt, *and slept out without any tent, and without keeping up a fire through the night?* If a Canadian surveyor's wife could do this, a Canadian surveyor can get to the north pole.

The next cold snap after this the thermometer reached −58° F., but it did not touch −60° again that winter. Not once during the winter did any of the party suffer from frostbite. I have repeatedly seen the men chopping bare-handed with the thermometer at −25° F.; and have myself taken observations of the North Star when it was −35° F. It was cold undoubtedly, but it was not as bad as taking the same observation in the mosquito season.

During the whole twelve months we were out we had not a day's sickness among us, but everybody was decidedly fattest and heartiest during the coldest weather. One fallacy we completely exploded—i. e., that extreme cold produces drowsiness. We never saw any indication of it, and since then I have traveled some thousands of miles across the ice of the Georgian Bay in temperatures varying from +32° to −30° F., and never experienced the slightest inclination to drowsiness. Only once in my life

have I felt it, and that was in the middle of summer, when as a very young man I was fool enough to try and walk fifty miles in a day without any previous training. During the last mile or two my companions had hard work to keep me on my feet, and at the end of the journey I subsided into a chair and went fast asleep, and in that condition was carried to bed, where I slept for twenty-four hours. I was simply "played out," and it is *that*—not cold—which produces the drowsiness so often referred to. More than once since then I have walked fifty miles on snowshoes and never felt anything of the kind, but I made it a rule to stop every four hours and brew some tea and eat a good square meal. When this practice is followed, it is astonishing how far a man can go without excessive fatigue. The "fatal drowsiness," as it is so often called (which is surely a near relation of "that tired feeling"), is nothing but Nature's final rebellion against a reckless overtaxing of the muscular power without renewing the waste, which of course goes on most quickly in cold weather.

A more recent example of the staying powers of Canadian surveyors is furnished by the exploration of the "Barren Lands" and Chesterfield Inlet just brought to a successful completion by the Tyrrell brothers for the Dominion Geological Survey. The party consisted of the two Tyrrells and six Indian canoemen, a model party for exploring purposes. The total distance covered by them in canoes from Athabasca Landing to Fort Churchill on Hudson Bay was two thousand two hundred miles, and thence to Winnipeg on foot or by dog train one thousand miles. Of the two thousand two hundred miles, eight hundred and fifty was through an entirely new country never before traveled by white men, and five hundred miles was over the open sea of Hudson Bay at the very worst season of the year, between the middle of September and the middle of October. It was during this trip down Hudson Bay that they endured the greatest hardships. They ran out of provisions, there was no wood along the coast, and on one occasion they were unable to land for forty-eight hours on account of the heavy sea. None but Canadians would ever have ventured on such a trip in canoes; none but Indians could have carried it through successfully. All the stirring incidents of this daring journey have been fully published by the press throughout the continent, and need not be recapitulated here. They prove conclusively that the boast of the Ontario Land Surveyors is based on recorded facts, of which any nation might be proud.

In considering the record of past failures in the arctic regions —for, in spite of the magnificent heroism displayed, they were nothing but failures—two points stand out clear and distinct, viz., that the pole will never be reached in ships, and that it can

never be reached by any such parties as have hitherto been sent out. The men who so freely risked their lives were not to the manner born, and what they were called upon to endure was so violently opposed to all their ordinary experience that they were heavily handicapped at the very start. With the uneducated seamen the resulting mental depression must have been a most difficult thing to combat, thus creating a double tax on the already strained nervous courage of their more highly educated leaders. British seamen are fine fellows and possess in a high degree the courage of their race, but nothing would induce a Canadian surveyor to lead a gang of them into the arctic regions, or even take them out on an ordinary bush survey. They would simply be useless. What are wanted are trained *voyageurs* who are equally at home in canoes or on snowshoes; and not too many of them. With the exception of Dr. Kane's (by far the most successful), arctic exploring parties have been too unwieldy. The one hundred and five ill-fated souls who abandoned the Erebus and Terror starved to death where a party like the Tyrrells' would probably have won their way back to civilization. Had Kane been backed up as he should have been, he would most likely have reached the pole, and when that point is attained, as it certainly will be, it will be over the course followed by him, and by means of dog trains and canoes or boats.

In spite of probable criticism, I am going to sketch a plan for reaching the north pole, drawing on my own experience and that of Canadian surveyors and explorers. I assume at starting that expense is simply no consideration whatever. If a feasible scheme is put forward, I believe that there is enough enterprise, private and governmental, among Anglo-Saxons to carry it through, even if it cost a million.

The exploring party would be carried by steamer to the head of summer navigation on Baffin Bay, where a depot would be established as a base of operations. Here provisions, houses, steam launches, sailboats, canoes, dogs and sleighs, fuel, and all the other accessories, with the exploring party, would be landed, and the steamer could return to winter at Upernavik or Disco. The former place is only one thousand miles from the pole, the distance covered on foot by the Tyrrells, in the middle of winter, with the thermometer often at −40° F., and without tents. A point to be considered is, whether it would not be well to have a second steamer built on the principle of the St. Ignace, the steam ferry at the strait of Mackinac. This boat made an extraordinary record on her trial trip, shearing through ice three feet thick with the greatest ease. With such a vessel, it might be possible to push a long way up Smith's Sound. That point could be determined by a preliminary survey of the head of Baffin Bay.

The main exploring party should be composed of fifteen men—five white men and ten Indians. The white men would be made up of three Canadian surveyors, for the scientific purposes of the expedition; one doctor, as a concession to popular prejudice; and one journalist or reporter to work with pencil and camera. As a journalist myself, I claim the right of the fourth estate to be represented. The Indians should be picked *voyageurs* from the Georgian Bay. These men are good canoemen, first-class sailors, are used to ice traveling, and have walked on snowshoes since they could walk at all. Above all, they are faithful workers and reliable men.

The main depot or base would probably be situated at the mouth of Smith's Sound, in latitude 78°. That point has been reached more than once, and can be again. But it is not necessary or expedient to push it farther than the ordinary head of summer navigation, because it would become a permanent meteorological station, and would ultimately be connected with Newfoundland by cable, a distance of sixteen hundred and eighty geographical miles. The buildings would be ordinary American frame buildings, framed on two-by-six scantling, and sheeted with four layers of matched boards, two outside and two in, with heavy felt paper between the sheeting. With double windows and double doors, such a building properly heated will defy the cold of space. The heating would be accomplished with hard coal and base-burners. The buildings of course would be taken up all ready to put together, and, with the labor available from the ship, ought to be ready for occupation in a fortnight. This base would have a resident staff of officials, mechanics, and *voyageurs*, whose duty it would be to take care of the supplies, and back up the main exploring party by pushing forward provisions and other necessaries as they advanced farther north. Subsidiary depots should be established every hundred miles until the pole or an open polar sea is reached. These minor depots would be nothing but tents of stout duck, of the Northwest tepee pattern, raised on light but strong poles of cedar, and spiked to the ice with iron or copper spikes. They would contain provisions, blankets, stoves, and fuel, and, as long as the main party was out, would be connected with the head depot by regular dog service. Three or even four of these would probably be located the first fall.

About the middle of the following April (Kane abandoned his ship on the 20th of May) the real work of the expedition would commence. The problem presented to the surveyors would be to overcome the seven hundred and twenty miles separating the main depot from the pole. At the lowest estimate there would be five months in which to do this, necessitating an average daily

advance of nine miles on the straight line, to take them there and back. As an actual fact they could travel for six or seven months if necessary, and the going would probably be better in winter than in summer, for snow is the traveler's friend in high latitudes.

The main party, with an interpreter for communicating with the Eskimos, would start out with sixteen dog teams carrying tents, stoves, fuel, blankets, etc., and two big Peterboro canoes. The fuel would have to be specially constructed. Coal is unsuitable and wood is too bulky. I know from personal experience that an ordinary porous brick soaked in coal oil for twenty-four hours will burn for over two hours, and makes a first-class torch for spearing fish by; and I do not see why compressed bricks made of sawdust soaked in coal oil would not make a capital fuel. In a properly constructed sheet-iron stove it would throw an intense heat and could be lighted in an instant. In summer time, of course, very little fire would be needed except for cooking, but after the thermometer got below zero fires would be necessary night and morning. The best fuel for the purpose could easily be determined by experiment, but whatever its character it must be compact in form and must yield the greatest possible combustion for its bulk. All provisions should be packed in sealed tin cases of a convenient size and weight for handling. They would then suffer no injury from rain. The tents should be conical in shape, eleven feet in diameter at the bottom, and stretched on ten light cedar poles hinged to a ring at the top, and shod with iron at the bottom. This is the most convenient tent made. It can be set or struck in less than a minute, because it opens and shuts like an umbrella. It gives the greatest floor room for the amount of canvas. There is no large space overhead to absorb the heat. And it offers the least resistance to the wind, and if properly spiked can not blow down—a valuable property when the thermometer is away below zero. Four such tents would accommodate the exploring party. The character and quantity of food would be easily determined by the surveyors, but one article would have to be sternly eliminated, and that is alcohol. My allowance for sixteen men for five months would be two bottles of brandy, and I think they would come back unopened. The traveler's standby in cold weather is tea, and men will do more hard work on it than they ever could accomplish on any form of spirit. Of course, there are many minor details which need not be enumerated here.

What difficulties the party would have to contend with above the eighty-second parallel, of course, can not be known. Their motto at starting would be, "Get there somehow," and there is no doubt they would live up to it. If the theory of a Polynia or

open polar sea is correct, they would take to the canoes and follow along the west coast of Greenland as far as it may project northward. The Tyrrells made five hundred miles over the waters of Hudson Bay in this way, and others can do the same. In all they did, however, the surveyors would be guided by past practical experience. If they had their choice they would probably prefer ice to water, but whatever came they would meet it with the equanimity of brave and resourceful men. Above all others, their training in the field has qualified them to cope with the difficulties they are likely to encounter.

It is quite probable that the pole would not be reached the first summer. From Mount Parry to the pole is five hundred and fifty miles. If the most northerly point of Greenland does not reach within a hundred miles of the pole and there were no islands visible beyond, they would scarcely trust themselves on a trackless sea in canoes. They would then have to return and commence the arduous task of portaging a good-sized steam launch piecemeal from the head depot to the polar sea. The whole freighting force of the expedition would be laid under contribution, and the work pushed with unflagging vigor. The boat, of course, would be specially constructed beforehand for the purpose, and would go together and be ready for navigation in a week. Allowing the launch a speed of six miles an hour, the pole would be reached in four days.

The way to accomplish a task of this kind is to go at it quietly and systematically, and stay right there until it is done. Ship companies have always been confronted with the terrifying possibility of being cut off from all human succor. My plan renders such a contingency impossible. The steamer would visit the main depot every summer and then sail for Newfoundland, whence news of the expedition would be telegraphed over the world. The members of the expedition could thus communicate with their friends, and the depressing feeling of isolation would be obviated. There would be no danger of running out of supplies, and the expedition could go cheerfully ahead with the assurance that their retreat was provided for.

There are many reasons why Baffin Bay and Smith's Sound should be chosen as the route to the north pole. To put them shortly: 1. Greenland is the most northerly land known, and probably extends a good deal farther than at present explored. 2. Smith's Sound has been already traversed as far as the open sea. 3. Upernavik is the most northerly permanent abode of civilized man. The moral influence of this on the expedition would be great, because it would be but a short distance from the main depot. 4. A whisp of the Gulf Stream runs along the west coast of Greenland as far as the seventy-eighth degree of latitude, rais-

ing the average temperature 9° F. above that of the east coast, and rendering summer navigation certain. 5. According to Réclus, the January isothermal of Frog Lake, where I wintered in 1883, twists northward until it runs through upper Greenland, so that, although the winter might be longer, it would not be more rigorous. The same authority concludes, from various ascertained facts, that within the Arctic Circle the summer mean increases as you get nearer the pole, and favors the theory of an open polar sea. It is certain that the pole of greatest cold lies southwest from Greenland among the western islands of the polar archipelago. Lastly, Disco possesses coal, the most important item in steam navigation.

From a consideration of the foregoing points the situation resolves itself into a simple question of money. If the funds are provided, the men are here who are both willing and qualified to carry the work through, and this article has been written as an appeal to both governments and individuals to come forward and once for all settle the scientific questions involved in the location of the north pole. Canada will bear her share undoubtedly, and, what is more to the purpose, will find the men. One difficulty which will beset the organizers of the expedition will be the necessity of dealing with the hundreds of volunteers who, for sentimental reasons, will move heaven and earth to get themselves joined to it. Most of these men will possess absolutely no qualification for the work, and would prove nothing but so much useless lumber. They must all be met with the same unbending negation. Finding the north pole will be no summer picnic. The men to accomplish it must be experienced middle-aged men, whose muscles have been indurated and their minds fortified by a constant acquaintance with cold, hardship, and danger, and nowhere except among Canadian surveyors can you find men who combine these qualities with the necessary scientific attainments. Science knows no nationality, and in a matter of this kind there should be no international jealousy. Let Anglo-Saxons find the money, and those Anglo-Saxons best fitted for the work will undertake it and carry it through.

There is but one more point to be noted. The next five years will be particularly favorable for arctic exploration. We are now approaching a minimum sun-spot period, which experience proves is coincident with a period of mild winters. The last minimum was in 1888, a year of extreme heat and drought followed by a winter of unusual mildness. Going back eleven years, the winter of 1877–'78 was so mild that wild geese remained on the Georgian Bay throughout the winter, and the Collingwood steamers were plying the first week in April—a month earlier than usual. The winter of 1882–'83, which I spent with Mr.

Abrey in the Northwest, was exceptionally severe and occurred during a maximum period. In our daily observation of the sun we watched the spots during the previous summer, and were astonished at their size and number.*

I can only add that when the expedition starts I hope to be one of the party. If it is organized on the lines I have laid down I should set out with an absolute assurance of getting there, and, what is of still greater importance, with an equal certainty of getting back again.

THE NEW MINERALOGY.

By G. PERRY GRIMSLEY.

MINERALOGY, as the *observation* of minerals, is of very ancient date, but such observation was very crude, for the old scholars grouped under one name a great variety of forms, some rocks and some minerals. The earliest writer was a Greek by the name of Theophrastus, who lived about three hundred years before the Christian era. A few centuries later the great naturalist Pliny recorded a number of personal observations. Then followed a blank period extending into the eleventh century, when Avicenna made his mineral classification. In this, the first classification, all minerals were divided into four groups—stones (= silicates), salts, inflammable bodies, and earths. In the next six centuries the only improvement was the substitution of term metals for earths. Through all these many years, it was the beautiful in form, luster, and color of the gems which attracted the attention of men both learned and ignorant. The question of origin was not considered; indeed, it was sacrilegious to think of such a problem, since these were objects of creation, whose genesis, like that of the gods, was not to be revealed to man. It was the work of many centuries to dispel these clouds of ignorance and superstition which blinded and hindered the advance of this study. The only light which did appear was that of the alche-

* From a consideration of Schwabe's sun-spot table I am inclined to believe that Parry's three voyages, extending from 1819 to 1825, were undertaken during a minimum period. Schwabe's table, of course, only commences in 1826, but it is certain that the minimum period must have fallen within the above years. On the first voyage Parry sailed completely through Lancaster Sound, which he found a wide and noble channel, clear of ice, and the color of the sea, and there is little doubt that had he possessed a fast steamer he would have made the Northwest passage instead of being forced to winter on Melville Island. Dr. Kane, on the contrary, was out at the close of a maximum period of exceptional length and severity, and he experienced the lowest mean temperature on record. It was during this very same period that the ill-fated Franklin and all with him were lost, the Erebus and Terror being abandoned after nineteen months' imprisonment in the ice.

mists, those wizards who vainly searched for the lucky stone which would transform all into gold. From the ashes of their fires comes as a heritage the application of heat and fusion to aid in investigation, but even the value of these was not clearly seen for several centuries thereafter.

Behind the clouds there was a light, and the time at last came for it to melt these away, revealing a vast new field for thought and study in the inorganic world. Men began to look more carefully at the objects near them, to observe the ways of Nature, and to attempt the solution of some of her mysteries; then it was seen that even in the inert stone there was a story to be read—an ever-changing story full of historical interest, if only one could read it.

It is interesting to note through these centuries the struggles for existence and advancement which finally brought forth, at the beginning of our era, mineralogy as a *science*. In the sixteenth century the work of Agricola laid the foundation for physical mineralogy. In the eighteenth century Cronstedt pointed out the distinction, so long unknown, between rocks and minerals, based on chemical properties. At the beginning of the nineteenth century came the work of Werner and Hauye. These men perfected the methods and made more accurate descriptions of minerals, thus becoming the founders of modern mineralogy, and making their respective countries, Germany and France, the centers for this study. During the present century the growth has been as rapid as it was slow during all the preceding centuries, so that at the present time its students nearly outnumber the species.

The study of the properties of minerals—physical, chemical, and optical—was carefully made and verified over and over again, but the question of origin was unsettled; in many cases it was even impossible to conjecture. So its devotees sought a means of revealing and proving this problem of origin, and then arose what we may term the *new mineralogy*. Germany and France have equal share in the honor of founding the science of mineralogy, but to France belongs the credit of original active investigation into the origin of minerals. This feature of new sciences is becoming quite prominent, and one would infer that there was a very great awakening in the scientific world, for we hear of the new astronomy, the new chemistry, and the new geology; but it is not so much new science, as old science studied by new methods brought about by the great underlying law of the universe, progression, which causes the new of to-day to become the old of to-morrow. The new mineralogy endeavors to solve the problem of origin by the reproduction, artificially, of the mineral using similar agents and like conditions, as in Nature. While attempts were made to reproduce minerals early in the century and even

near the end of the preceding one, the important work has been done since the year 1850, which date may be taken as the beginning of synthetic mineralogy. Through the eighteenth century came many suggestions on the artificial formation of minerals, followed by the crude attempts at the reproduction of petrifactions and incrustations. Unsuccessful attempts finally led to the successful reproduction of marble by James Hall in 1801, the first mineralogical synthesis and the beginning of experimental geology.

The first workers, as would be expected, were chemists; among whom Daubrée stands pre-eminent. When the mineralogists joined in the work, it was found that the conditions governing the chemist's experiments differed from those they could apply. It was early discovered that the forces at work in the formation of minerals escaped the observation of the mineralogists, and, though observed, were considered outside the domain of chemistry. The chemist's aim was to form a mineral *like* the one found in Nature; but the mineralogist, in addition, must use analogous processes to those in Nature. In the chemical sense if the artificial product had the correct chemical composition, reaction, physical properties, such as density, boiling point, and the like, the synthesis was complete. On the other hand, in the mineralogical sense there must be also an entire agreement of the resulting product with the natural one morphologically. It must have the crystal form and also the characteristic type as in Nature, with the same optical properties, in order to be perfect. Thus the chemist could deposit copper by electrolysis, like the copper found in Nature; but this does not show the origin of copper in Nature. His task is the easier one, for he uses his reagents at pleasure, aiming only at the final product. In the course of time, the chemist and mineralogist seeing their mutual needs, united their efforts, and it is on this union that mineral synthesis as a science rests.

The cause of the long delay in the progress of this line of study was the idea, so firmly fixed in the minds of the old chemists, that Nature worked by mysterious means and had at her disposal indefinite time and enormous masses with supposed forces out of all proportion to those used in the laboratory. Then how was it possible in a crucible with a certain number of grammes of matter to reproduce a crystal of the same kind and association as those which the volcano ejected—a crucible a million times larger and under enormous pressure and temperature? The answer seemed too clear to even admit of such a vain attempt; they could not see the *law of proportion* which existed there, but it only needed progressive men to discover it. Even when this law was discovered, the crude means and limited experience at hand

retarded them and made the progress very slow down to the middle of the present century.

At the beginning of the cycle there existed the two opposing geological camps, the one attributing everything to fire, the other all to water; after long years of wrangling their union was accomplished through the efforts of Lyell and his followers. In addition to this, the accumulating observations overthrew two old ideas—namely, that a mineral can only originate in one way characteristic to it, and a single homogeneous magma can give rise to only one mineral. It was found that a mineral may originate under different conditions which are determinable, and that the homogeneous magma may at the same time give rise to different minerals. The various mineralogists appeared to take pleasure in throwing an envelope of mystery around the origin of minerals, and they were regarded, even by Zirkel, as the work of a kind of vital force.

Practical difficulties deterred the progress of the study; the crystals formed were sometimes imperfect and usually microscopic. So it was almost impossible to study them before the development of mineralogical micrography and the advent of the mineralogical microscope. Then it was found that these minute imperfect crystals were of more value and led to greater results than the more beautiful cabinet specimens, for they settled the problems of origin. Natural crystals were found to contain small inclusions which are indices to the origin. If these are vitreous, then the origin is vitreous, and the action of volatile agents is wholly excluded; if these be aqueous, the intervention of water is indisputable. In certain minerals—as quartz, beryl, topaz—liquid carbonic acid appears as an inclusion, giving evidence of their formation under great pressures.

From this brief survey we see the strong prejudices of the ancients are disappearing; observation and the processes of investigation have acquired a remarkable precision; materials and apparatus in the laboratories have been perfected to a remarkable degree.

Under the head of artificial minerals we exclude those accidentally formed in the industrial works, as graphite on the walls of iron furnaces, for such do not answer the question of their origin, since the reagents and conditions remain unknown. Nevertheless, the recorded observations of such products have aided reproduction in the laboratory, and it is of interest that these observations have been noted especially by German workers, while the home of active laboratory investigation is in France. The Germans collected the facts, while the French co-ordinated them, forming hypotheses and then experimenting to prove them. The Russians followed with almost equal success; also much important work has been done in the laboratory by the Germans.

The practical side of a subject must always be considered, the question of utility being a very important one. What claim has this subject for attention and what has it accomplished? It has thrown light on the mode of the natural formation of minerals and rocks. Thus even down to late time water was thought to play an important part in the formation of a great number of volcanic rocks and to be indispensable in the formation of the great group of rocks termed *basalt.* Yet basalt and all the modern volcanic rocks have been formed by purely igneous fusion. Again, certain minerals—as chiastolite, garnet, staurolite, and a large number of metamorphic minerals—are always found impure in Nature, and their exact composition was unknown until reproduced artificially. The majority of natural minerals are complex combinations in which many bodies are introduced by isomorphous agency. Synthesis has furnished the theoretical types and given forms which could be accurately measured and show the true physical properties.

Mineral synthesis determines the individuals belonging to a family and distinguishes the true isomorphism of the series in question. The artificial reproduction of the feldspar series proved that the two members, *albite* and *anorthite,* were isomorphous and could be united in all proportions, some new forms being found which were unknown in Nature. Other mineral types which are suggested by, but are absent in Nature have been formed artificially, thus completing a mineral series, making the limits of isomorphism more clear. This was accomplished by Ebelmen in the spinel family, showing the relation of ferrites, chromates, and aluminates to each other; also by Foque and Levy in the feldspar family, who formed new feldspars with bases of lithia, barytes, strontium, and lead. This work has also been of great assistance to geology, a science which has been encumbered by theories and hypotheses, where observation was in very many cases insufficient to settle definitely the doubts. Synthesis, when applied, enlarged the field of observation and so often furnished definite solutions. Thus the origin of granite was one of the great problems confronting geologists. The opinion that it was purely igneous prevailed in the science for the first part of our cycle, replacing the Neptunist or aqueous theory of Werner, but the difficulties were increased a little later when, by means of the microscope, it was found the quartz was consolidated after the other minerals; this was against the idea of a purely igneous fusion of the granite. The upholders of this theory then argued for an extra fusion of the quartz analogous to sulphur. Élie de Beaumont in 1849 modified the theory by admitting the intervention of water. For proof he called attention to the number and frequency of the minerals sublimed on the pe-

riphery of the massive granites. He thought the water occurred in the form of inclusions in the granite constituents, which was proved ten years later by Sorby. From this time on there was the new theory for a mixed origin of granite. When synthesis was applied it was found impossible to obtain granite by purely igneous fusion.

The new mineralogy has accomplished much and has extended our knowledge of rocks and minerals far beyond even the dream of its founders, so that to-day nearly all known rocks have been formed artificially with the same minerals and under the same associations as in Nature. Of the different mineral species but very few remain which have not been reproduced in the laboratory, and each year decreases this number. The only ones which have not been reproduced are *epidote, allanite, zoisite, staurolite, disthene, andalusite,* and *tourmaline,* a very small number, which will probably be removed in the next few years. All this work has been accomplished in a comparatively short period of time in three countries, France, Russia, and Germany.

Thus we see the new mineralogy has given breadth to the old and has established a better foundation on which to build, since it has disclosed the long-hidden mystery of the origin of minerals and rocks.

SCIENCE AS A MEANS OF HUMAN CULTURE.*

By FLOYD DAVIS, E. M., Ph. D.,
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THE day has long since passed when men expected to meet with success without faithful effort. We now realize that one of the fundamental principles underlying success in any field is concentration of thought and energy in rightly directed channels. We are glad to see so many of our higher institutions of learning, particularly the technical schools through their laboratory methods of instruction, training young men to concentrate their energies. The beneficent results of such training will be enjoyed by generations to come.

The trained intellect grasps in a comprehensive manner details which the untrained can never see; it analyzes subjects in all their bearings and gives wise direction to the advancement of truth. In all scientific work, and even in the business world, the demands are for men trained to comprehend subjects down to the very details in a single glance. A business firm once employed a

* An address delivered at the formal opening of the New Mexico School of Mines, at Socorro, September 5, 1893.

trained young man whose energy and grasp of affairs soon led the management to promote him over a faithful and trusted employee. The old clerk felt deeply hurt that the young man should be promoted over him, and took occasion to complain of it to the manager. Feeling that this was a case that could not be argued, the manager asked the old clerk what was making all the noise in front of their building. He went forward and returned with the answer that it was a lot of wagons going by. He then asked the clerk what they were loaded with, and again he went out and returned, reporting that they were loaded with wheat. The manager again sent him to ascertain how many there were, and he returned with the answer that there were sixteen. Finally he was sent to see where they were from, and he returned, saying that they were from the city of Lucena. The manager then asked the old clerk to be seated, and sent for the young man, and said to him, "Will you see what is the meaning of that rumbling noise in front?" The young man replied: "It is unnecessary, for I have already ascertained that it is caused by sixteen wagons loaded with wheat. Twenty more will pass to-morrow. They belong to Romero & Co., of Lucena, and are on their way to Marchesa, where wheat is bringing one dollar and twenty-five cents per bushel, while it costs only one dollar at Lucena. The wagons carry one hundred bushels each and get fifteen cents per bushel for hauling." The young man was then dismissed, and the manager turning to the old clerk said, "My friend, you see now why the young man was promoted over you." This illustrates the tendency of our times, for we are rapidly advancing into an age when concentration of energy and grasp of a subject in detail in the shortest possible time are requisite for advancement.

This is largely an era of material progress, and the training which is needed most for the rising generation—especially here in the West—is that which will fit it for the application of its best efforts to the noblest purposes of life. The preparation for this work must come through our schools. Teaching here involves three distinct processes: instruction, or the imparting of knowledge; education, or the development of the faculties; and training, or the formation of habits of thought and work. The master teacher has a happy combination of these three processes, no matter whether it be in the primary grades, the college, the university, or the technical school. In the elementary schools instruction necessarily predominates; in the college and university, the educational; while in the school of technology, the element of training is the most important. And I believe that the principal work of a technical school like this should be the training of young men in accurate methods of thinking and working.

Too many of our teachers in all grades of schools confine themselves too closely to the element of instruction, and many of them fail to recognize the importance of education and training. This is, perhaps, owing to the delicacy which the instructor's work assumes in the educational stage. Here the teaching should be full of suggestions and sympathetic guidance to develop the reasoning faculties and guard them against inaccurate and discursive habits. In the technical school there is a certain amount of preliminary instructional and educational work that must be done, without which no real progress in thorough and systematic training can be made. But this is a condition, I think, that is not fully appreciated by some of our technical schools. While I believe most thoroughly in elementary instruction and advanced education, I fear that too many of our higher institutions of learning neglect the importance of scientific drill, discipline, and mental gymnastics, on which the development and value of the mind as an instrument for the acquisition of real knowledge so much depend. Wrongly directed education, often so painfully acquired, lies like rubbish in the mind; it can not take root and quicken into life and grow, for the means are mistaken for the end, the working machinery is mistaken for the finished product. The great difficulty lies in too many young men to-day being overtaught in the hypotheses and undertrained in the realities of life. We need more practical education and training, and possibly less speculative philosophy. This is demonstrated by the outcry that comes to us from Germany against overeducation. But there is certainly not too much practical education: generations will come and pass away before there will be danger of that. Still, this protest, coming as it does from one of the most intellectual countries of the world, where speculative philosophy flourishes most, will have its reaction in our leading institutions of learning, and will give us a deeper appreciation of practical education.

The present educational methods being inductive and reflective, pertain more to the realities of life and less to its graces than the theories held half a century ago. The new education teaches us that it is unwise to spend the best years of one's life pursuing studies that are merely cultural, for most of us certainly have as much need of knowledge as of culture. We send our children to school to seek for knowledge, for we know that when they study for the love of knowledge culture will come as an incident in the attainment of it. The thing formerly considered was only mental discipline, and the result was depression; while the object now is to keep the mind alert, expectant, and enthusiastic by presenting the delights and rewards of learning. We now teach our boys to realize the activities of their own senses, to see that knowledge only comes to them through these avenues,

and only as it thus comes is it entitled to be considered real knowledge. We now study subjects for what there is in them, so that the knowledge gained may be a help to thought; and the enthusiasm thus acquired begets new ideas. The youthful mind requires something tangible to grasp, or the reasoning faculties are slowly developed. In all scientific works, facts are used as an index to ideas, which is not a tax upon memory, but a stimulus to the intellect. Still "it is not for its facts, but for the significance of its facts, that science is valuable."

The time is forever past of the old idea that the study of the ancient classics, mathematics, and humanities is the only education. And the once popular notion that a broadly educated man is a sort of intellectual reservoir that can be tapped for all sorts of miscellaneous information is equally absurd. The social consideration which once attached to persons supposed to know Latin and Greek, whether gentlemen or not, has been abandoned, and the test of social rank now is what they are and not what they are supposed to be.

The benefits generally claimed to come from a classical education are that it affords an admirable intellectual training, opens up a magnificent literature, and contributes very largely to the right understanding of our native tongue. This is certainly all true, but such intellectual training is derived as easily from other sources, for when the modern languages are taught systematically they are useful in the same way, if not in the same degree; while the natural and physical sciences are admitted now by our best thinkers to be the most powerful agents in the development of the intellect. Their literature, to the great majority of university men is unknown; but the scholar who has laboriously studied for a dozen years or more over his Virgil and Sophocles is generally but little better acquainted with ancient literature than he who has spent a year upon adequate translations of the famous originals. And the understanding it gives us of our own language, which in utility means accuracy, grace, and ease of expression, might, I dare say, be more easily attained in boyhood through formative habits, if guided scientifically, rather than through the endless mysteries of syntax and inflection.

The study of the classics is no longer essential, except in traditional schools. A well-known New York book merchant recently said, when asked about the demands for works on Latin and Greek: "We keep very few of the classics, and it doesn't pay to stock up any more. There is absolutely no demand for them, and a perfectly equipped bookstore can be sustained nowadays without a single classic on the shelves. Probably five times a year we have a call for one, and it doesn't pay to keep a stock for these stray demands." How many modern orators employ quotations from

Cicero, Demosthenes, or Plato? Probably not one in a hundred. But formerly, when Emerson, Phillips, Holmes, Everett, and Alcott were on the lyceum platform, it was necessary for those who heard them to have a knowledge of the classics to intelligently follow them. Times have changed and the natural and physical sciences have taken their place. These offer the greatest advantage in holding the student's attention, stimulating thought, and cultivating the spirit of true investigation; they require the strictest habits of observation, induce concentration, arouse energy, educate the senses, train the hand to delicate manipulation, quicken the faculties of reasoning and powers of judgment; and the varied and useful information which they afford is given in the clearest and most convincing form. When pleasure and desire of learning are fostered together under these influences the amount of knowledge gained will be proportional to the time and opportunity for study.

In science, the student feels that rules are merely summary expressions of a number of concrete facts; and he familiarizes himself with methods of proof, and accepts only that which is susceptible of proof. It is in this way that the sciences become one of the most important means at our command for moral and intellectual training. When studied in a reverential spirit they develop the most intense desire for truth and inculcate an equal hatred for all pretense and falsity and an intolerance of all dogmatism and bigotry. They offer the same evidence for acceptance that they demand for conviction; and in the facts which they discover every theory is tested by being put on trial. All true scientific structures are builded on knowledge and not on faith, on proof and not on current opinion, for all opinions, preconceived notions, hypotheses, and even accepted doctrines are held in abeyance until the evidence is in and has been duly weighed. That mind and manhood are thus trained alike in a pre-eminent degree by the systematic study of the sciences is now beyond dispute. Many of the older classical colleges have abandoned some of their traditions to make room for these comparatively modern studies, which shows how general has become the appreciation of science as a means of intellectual and moral training, when taught by the laboratory method.

But beyond all these acquirements is the judicial attitude of mind which comes as a supreme characteristic of scientific study. In his investigations the true scientist endeavors to present absolute fairness toward all evidence and offers no resistance to its conclusions. His mind thus opens itself to all the avenues of truth, and he welcomes all the results of his investigations with equal cordiality.

Owing to peculiarities of the eye, ear, and brain, investigators

of equal intelligence, training, and experience in their conclusions will generally differ from one another by a constant or nearly constant quantity, and each will differ from the truth. This difference from the truth in each individual is his personal equation or habitual error. Many investigators now correct their results for this constant error, but nowhere in the realm of knowledge are the processes for making this correction so perfectly worked out as in the physical sciences, geodesy and astronomy. A party of astronomers was once about to be sent on service to the southern hemisphere. Their personal equations were carefully ascertained, when it occurred to one of them that in the hemisphere to which they were going the apparent celestial movements would be reversed, and that their errors ought to be reinvestigated for stars of apparent reverse motion. This was done, when the differences were found to be oppositely as large as before. There was, however, one individual in the party to whom it mattered not which way the stars moved, for he had no personal equation in either case.

It is the duty of the scientist to sift facts from theory, and he who is thus engaged constantly in separating what is really known from belief or mere theory gains intellectual strength and an appreciation for true honesty. The ability to weigh evidence and distinguish between it and the flights of the imagination is the natural foundation of greatness in all scientific work; and in proportion to his ability to rise into this lofty realm is a man's opinion and work entitled to authority.

The natural and physical sciences demand our attention on account of their technical applications in the arts, and the admirable preparation which they give for all practical work when concrete things are the objective study. The colleges that teach pure mathematics, languages, history, and philosophy, without their application to the affairs of mankind, do not get beyond the threshold of education. They merely place in their students' hands tools for work without training them in their uses, or to appreciate the variety and beauty of their finished product. It is certainly a high and responsible calling to instruct young men from text-books in what has long been accepted as truth, but the higher functions of a true education rise into the sphere of application and original investigation; and I believe the few institutions that strive to this end are doing more for the real intellectual advancement of mankind than all the traditional schools on record. Without the application of the instruments of knowledge, the pretense and self-stultification born in the class room often result in the dangerous and pernicious idea that it is better to be brilliant than to be sound, better to rely on opinion and faith than on experiment and knowledge. Too

many of our classical colleges are yearly grinding out their grists of such intellectual chaff, for it would seem that the higher university classical education often unfits its recipients for anything except routine work, and they crowd into and often dishonor the so-called learned professions, and then make their living in questionable ways, or starve. In the great cities of Germany the poor boards are constantly called upon to relieve men of the highest classical training, because they can not make a living in their chosen field of work, and are unfitted for the trades and arts. Horace Greeley must have had in mind this kind of education when he exclaimed, "Of all horned cattle, deliver me from the college graduate!"

The colleges that accomplish the most good turn the students' attention to the demands of the times, and thus fit them for the most honorable walks of life. One of the supreme advantages that is derived from a technical education is that it does not unfit men for labor; but from its very method of acquirement—the laboratory—it teaches us that labor is the highest application of the intellect, and the only perfect means of acquiring real knowledge. Nor are the rewards of scientific education to be undervalued, and the industrial opportunities of the scientist to be overlooked.

The wonderful progress in the development of the natural and physical sciences has come through the agency of experiment and comparison. In this, the scientific method, the student at his home masters the text-books; in the library and reading room he studies the works of the best authors and investigators; in the lecture room he is drilled in theory and application; and in the laboratory he puts questions to Nature and receives her replies; and thus develops strength in all the faculties of a true investigator. Liebig, in chemistry, was the first to adopt teaching by experiment about fifty years ago; but other scientists, one after another, have since adopted the laboratory method, until it is now advocated in language, philosophy, literature, and even law.

The exigencies of modern progress in the arts demand that technical institutions of learning shall keep abreast of the times, and this is especially true in regard to schools that profess to turn out practical chemists, geologists, mining engineers, and metallurgists, thoroughly equipped to take immediate charge of important enterprises, or to advise as to investments in new and untried fields. The advances which are now being made in the practice of analytical and industrial chemistry and metallurgy, and in nearly all allied industries, are so rapid that methods described in text-books written for the use of students often become obsolete by the time the books are published.

The training of the specialist requires the most stimulating influences, and the process should be one of continuous and well-directed effort. If we learn, step by step, what Nature has in store for us, without hurry, we incur a minimum cerebral fatigue and a maximum acquirement. A strong constitution is required for successful work in any pursuit. The natural and physical sciences promote this because their study begets cheerfulness; they make life pleasant and interesting, and instead of injuring the nervous system as many other studies do, they give it tone and vigor in much the same way that manual exercise gives strength to the muscular system.

I believe that in some of our technical schools which provide for the most thorough and scholarly study of principles directed immediately upon the useful arts, and rising in their higher grades into original investigation and research, is to be found the ideal education for young men. Too long have these institutions been branded as furnishing only an inferior education to the so-called liberal arts, because it is practical and useful. Too long have they been regarded as furnishing only an inferior substitute for the classics, and their graduates have been spoken of as though they had acquired the art of livelihood at some sacrifice of mental development and intellectual culture. It is true that form and style may be sacrificed in the earnest, direct, and laborious endeavor of students of science, but that all the essentials of intellect and character are happily developed in these schools is thoroughly demonstrated by the eminent success of their graduates. When measured by the only true standard of intelligence, that of use in the world, these men will rise through their work and power of gaining knowledge to high positions of usefulness and influence.

The demands of the times have forced us to a high appreciation of specialization in all departments of knowledge, and he who attempts on general attainments to cope with advanced problems in practice generally meets with defeat in much of his work. A mere smattering of knowledge no longer suffices in professional pursuits, and the proverb—

> "A little learning is a dangerous thing;
> Drink deep, or taste not the Pierian spring"—

is too often realized by those who attempt work for which they are not fitted by professional training, or by those who have scattered their capacities over widely diversified fields. The weakest individual, by concentrating his energies on a single pursuit, may meet with success; but the strongest, by distributing his powers over many, may and often does fail to accomplish anything. Berzelius said that he was the last general chemist, and the single

science of chemistry has grown to such enormous proportions that no one since his day has ever attempted mastery of the whole field. This being true, what can be said of the vast field of all natural and physical science? Those who attempt to cover it, or even a goodly portion of it, can not get much beyond the nomenclature used. The best results are always accomplished by co-operation and differentiation in work. The material progress of our times is due largely to the division of labor, which thus enables each individual to perfect his own skill. In my work as a chemist and metallurgist I am compelled to have a general working knowledge of all allied sciences, but by taking the results of the investigations of my fellow-workers, each in his own field, I am enabled to give more of my time to my own specialty, and therefore to accomplish what I could not do were I "a Jack of all trades." And it may be hoped that my investigations will in their turn come to the aid of the sanitarian, the pathologist, and the engineer. But more than this is required in this day of sharp competition, for it is becoming necessary for the specialist, not merely to confine himself to one subject, but to know more about some particular branch of his subject than does any one else. Those who pursue these special lines are the real investigators, and they give us the advanced scientific knowledge which we now enjoy.

The opportunities of the specialist are many and inviting. Every field of technical work opens up a magnificent series of unsolved problems, the solution of which will bring honor to the discoverer and benefit to the world. Technical chemistry, applied electricity, and metallurgy are yet in their infancy, but what grand achievements they have already made! Many of the greatest advances in modern civilization and the comforts of life have come through these channels. The brain and hand of the trained scientist transform the crude materials of the three kingdoms of Nature into things of beauty for the wants of men. The clay in the bank, the ore in the mine, the wood in the forest, by passing through his hands, take on the form of his thoughts and become expressions of his skill and power.

Specialization in knowledge carries innumerable advantages with it. The thoroughly educated scientist is acquainted with the ablest writers in his field, and reads and comprehends them. He appreciates their ideas and employs their knowledge and experience for his own purpose. If he decides that a process is imperfect, he knows in what direction improvement is needed. He is not misled by undetermined elements or impracticable theories, but through his knowledge of facts bases his conclusions on substantial grounds. He is prepared for any emergency and adapts himself quickly to his surroundings, for his scientific

training enables him to apply himself in practice with the least difficulty and to the greatest advantage. Those who are trained in this way are always in demand, and their valuable services bring the highest financial returns.

Finally, I advocate technical education and specialization, because I believe that they are the most perfect means of securing good citizenship; for when the head and the hand are properly trained, the heart will respond to the noblest dictates of truth and virtue. But in addition to these attainments, I also believe implicitly in the broadest and most scholarly education in all that is useful and good. The specialist, as I have described him, feels the need of broad scholarship for its professional utility. In a court of justice an expert frequently calls into use sciences that have only a remote bearing upon his profession, as well as to present to the court the breadth of his scholarship and his experience. In one case a chemist may in the examination of an ore be called upon to use his knowledge of mining, metallurgy, mineralogy, and geology; in the examination of a drug he may be required to have a knowledge of pharmacy, botany, materia medica, and therapeutics; in another case his examination of a water may call into use a thorough knowledge of physics, pathology, and sanitation; while in another case of suspected criminal poisoning, when the life of the accused may rest largely in his hands, he is required to have a profound knowledge of the details of toxicology, jurisprudence, and microscopy. In fine, the sciences are so blended that a profound knowledge of one can only be acquired through the instrumentality of all the others, and the expert in the course of his professional experience will be called upon to bring into use all the various departments of useful human knowledge. Education for such professional service is a knowledge of how to use the whole of one's self, to apply the faculties with which one is endowed to all practical purposes. A liberal technical education broadens our views, removes prejudice, and causes us to welcome the views of others, and we no longer consider our methods the only ones worthy of adoption. It keeps us out of ruts and makes us desirous of being benefited by the experiences and teachings of others. It stimulates great mental activity, and thus leads to skill, investigation, discovery, and improvement.

It is proposed by a M. Lotz to apply photography to the testing of bridges. Photographs are taken from a convenient spot, of the bridge unloaded and of the same weighted with the heaviest burdens it is intended to carry. The difference in the appearance of the photographs will show the extent to which the bridge yields or sags under the loads put upon it.

PARASITIC AND PREDACEOUS INSECTS.*

By C. V. RILEY, Ph. D.

THE importance to man, and especially to the horticulturist, of the parasitic and predaceous insect enemies of such species as injure vegetation has been recognized by almost all writers on economic entomology. Indeed, it is a question whether the earlier writers did not attach too much importance to them, because while in the abstract they are all essential to keep the plant-feeding species in proper check, and without them these last would unquestionably be far more difficult to manage, yet in the long run our worst insect enemies are not materially affected by them, and the cases where we can artificially encourage the multiplication of the beneficial species are relatively few. While fully appreciating the importance of the subject, therefore, it is my purpose in this paper to point out the dangers and disadvantages resulting from false and exaggerated notions upon it.

There are but two methods by which these insect friends of the farmer can be effectually utilized and encouraged, as, for the most part, they perform their work unseen and unheeded by him, and are practically beyond his control. These methods consist in the intelligent protection of those species which already exist in a given locality, and in the introduction of desirable species which do not already exist there.

In a few cases like this there is no reason why the farmer should not be taught with advantage to discriminate between his friends and his foes, and to encourage the multiplication of the former; but, for the most part, the nicer discrimination as to the beneficial species, some of the most important of which are microscopically small, must be left to the trained entomologist. Few of the men practically engaged in agriculture and horticulture can follow the more or less technical characterization of these beneficial species, and where the discriminating knowledge is possessed it can, as just intimated, only exceptionally be turned to practical account.

In other cases much good may be done without any special knowledge of the beneficial forms, but as a result of a knowledge of the special facts, which enable the farmer materially to encourage the multiplication of parasitic species while destroying the plant-feeding host. Very good illustrations of this kind of work are afforded by the rascal leaf-crumpler and the common bag worm, both of which in the larva state live in cases, and

* Condensed from a paper read before the Association of Economic Entomologists at Madison, Wis., August 15, 1893.

are much affected by parasites, and neither of which can survive if the cases are plucked in winter and placed away from any trees or shrubs, while under these circumstances the parasites will perfect and escape.

It is quite different with the second method of dealing with beneficial insects which I have mentioned, for here man has an opportunity of doing some very effective work. It is only within comparatively recent years that the importance of this particular phase of the subject has been fully realized. Various more or less successful efforts have also been made, and the transmission from one place to another of certain parasites of the plum curculio; of certain parasites of the common oyster-shell bark-louse of the apple; the successful colonization in France of a certain mite which attacks the grape phylloxera; the efforts to send parasites of plant-lice from Europe to Australia; the introduction into this country of *Microgaster glomeratus*, a common European parasite of the cabbage worm, and of *Entedon epigonus*, a common European parasite of the Hessian fly—are matters of record in State and Government publications.

In 1887 and 1888 the now well-known importation of *Vedalia cardinalis* from Australia and New Zealand to California to prey upon *Icerya purchasi* was successfully carried out. The history of this striking example of the beneficial results that may in exceptional cases flow from intelligent effort in this direction is now sufficiently well known to American economic entomologists, but anticipating that we shall have foreign delegates among us, and that our proceedings will be published more widely than usual, it will perhaps be wise to give the salient historical facts in the case, even at the risk of some repetition of what has been already published.

The fluted scale, otherwise known as the white or cottony-cushion scale (*Icerya purchasi* Maskell), is one of the largest species of its family, and up to 1883 had done immense injury to the orange groves and to many other trees and shrubs of southern California. From Australia, its original home, it had been imported into New Zealand, South Africa, and California—the evidence pointing to its introduction into California about 1868, and probably upon *Acacia latifolia*.

In my annual report as United States Entomologist for 1886 will be found a full characterization of the species in all its stages; but the three characteristics which most concern the practical man and which make it one of the most difficult species to contend with are its ability to survive for long periods without food, to thrive upon a great variety of plants, and to move about throughout most of its life.

The injuries of this insect, notwithstanding the efforts to check

it, kept on increasing, and some ten years ago I felt that the work of this particular species and of others which seriously affected the fruit-growing interests of southern California, justified the establishment of agencies there. Up to this time no special entomological efforts have been made by the Government on behalf of the fruit-growers of the Pacific coast. Through agents stationed—the one at Los Angeles, the other at Alameda—a course of elaborate experiments was undertaken as to the best means of treating the insects affecting the orange there, and more particularly this fluted or cottony-cushion scale. During the progress of these investigations, however, the fact impressed itself upon my mind that we had here an excellent opportunity of calling to our aid its own natural enemies; for while there were at first some doubts as to the origin of this icerya, the question was finally settled to my satisfaction that it was of Australian origin, that in its native home it was not a serious pest, but was kept subdued by natural checks.

A clause in the bill appropriating for the division of entomology prohibited the sending of agents abroad and prevented at the time independent action by the Department of Agriculture; but with the co-operation of the Department of State an arrangement was finally made by the Hon. Frank McCoppin, United States Commissioner to the Melbourne Exposition, whereby two agents of the Division of Entomology were sent to Australia, one of them specially charged with the study and importation of the natural enemies of this insect.

It was thus that Mr. Albert Koebele, in the fall of 1888, was sent to Australia for this special purpose. The history of Mr. Koebele's efforts has been detailed from time to time in Government publications and in the press, especially that of California. It suffices to state that a number of living enemies, both parasitic and predaceous, were successfully imported, but that one of them (*Vedalia cardinalis*) proved so effective as to throw the others entirely into the shade and render their services really unnecessary. It has so far not been known to prey upon any other insect, and it breeds with surprising rapidity, occupying less than thirty days from the laying of the eggs until the adults again appear. These facts account for its exceptionally rapid work, for in point of fact within a year and a half of its first introduction it had practically cleared off the fluted scale throughout the infested region. The expressions of two well-known parties may be quoted here to illustrate the general verdict. Prof. W. A. Henry, Director of the Wisconsin Agricultural Experiment Station, who visited California in 1889, reported that the work of the vedalia was "the finest illustration possible of the value of the department to give the people aid in time of distress, and the distress

was very great indeed." Mr. William F. Channing, of Pasadena, son of the eminent Unitarian divine, wrote two years later:

"We owe to the Agricultural Department the rescue of our orange culture by the importation of the Australian ladybird (*Vedalia cardinalis*).

"The white scales were incrusting our orange trees with a hideous leprosy. They spread with wonderful rapidity, and would have made citrus growth on the whole North American continent impossible within a few years. It took the vedalia, when introduced, only a few years absolutely to clean out the white scale. The deliverance was more like a miracle than anything I have ever seen. In the spring of 1889 I had abandoned my young Washington navel orange trees as irrevocable. Those same trees bore from two to three boxes of oranges apiece at the end of the season (or winter and spring of 1890). The consequence of the deliverance is that many hundreds of thousands of orange trees (navels almost exclusively) have been set out in southern California this last spring."

In other words, the victory over the scale was complete, and will practically remain so. The history of the introduction of this pest; its spread for upward of twenty years and the discouragement which resulted; the numerous experiments which were made to overcome the insect; and its final reduction to unimportant numbers by means of an apparently insignificant little beetle imported for the purpose from Australia, will always remain one of the most interesting stories in the records of practical entomology.

The vedalia has since been successfully colonized at the Cape of Good Hope and in Egypt, and has produced the same results in each case. In Egypt the vedalia was introduced to prey upon an allied species of icerya (*I. ægyptiacum*). We hope soon to be able to send the same insect to India, where it has recently transpired that *Icerya ægyptiacum* occurs; while recent information received from Phra Suriya, Royal Commissioner of Siam, at Chicago, would indicate that its introduction into Siam for the same or a closely allied insect will be desirable in the near future.

In fact, the success of the experiment was so striking and so important, and resulted in the saving to California of an industry of so great a money value that it has given rise, not only in the popular mind but in the minds of a certain class of entomologists also, to the idea that remedial work against injurious insects should be concentrated upon this one line of action, and that our best hope for their destruction lies with the parasitic and predaceous species, not to mention fungous and bacterial diseases. From an extreme of comparative incredulity the farmer and fruit-grower have gone, perhaps, to the other extreme of too great

faith. The case of icerya and vedalia, as I have frequently pointed out, was exceptional and one which can not easily be repeated.

One of the numerous phases of the vedalia experiment is that the wide newspaper circulation of the facts—not always most accurately set forth—has brought me communications from all parts of the world asking for supplies of the renowned little lady-bird for use against injurious insects of every kind and description, the inquiries being made, of course, under a misapprehension of the facts.

While this California experience thus affords one of the most striking illustrations of what may be accomplished under exceptional circumstances by the second method of utilizing beneficial insects, we can hardly expect to succeed in accomplishing much good in this direction without a full knowledge of all the ascertainable facts in the case and a due appreciation of the profounder laws of Nature, and particularly of the interrelations of organisms. Year in and year out, with the conditions of life unchanged by man's actions, the relations between the plant-feeder and the predaceous and parasitic species of its own class remain substantially the same, whatever the fluctuations between them for any given year. This is a necessary result in the economy of Nature; for the ascendency of one or the other of the opposing forces involves a corresponding fluctuation on the decreasing side, and there is a necessary relation between the plant-feeder and its enemies, which normally must be to the slight advantage of the former, and only exceptionally to the great advantage of the latter. This law is recognized by all close students of Nature, and has often been illustrated and insisted upon by entomologists in particular, as the most graphic exemplifications of it occur in insect life, in which fecundity is such that the balance is regained with marvelous rapidity, even after approximate annihilation of any particular species. But it is doubtful whether another equally logical deduction from the prevalence of this law has been sufficiently recognized by us, and this is that our artificial insecticide methods have little or no effect upon the multiplication of an injurious species except for the particular occasion which calls them forth, and that occasions often arise when it were wiser to refrain from the use of such insecticides and to leave the field to the parasitic and predaceous forms.

It is generally when a particular injurious insect has reached the zenith of its increase and has accomplished its greatest harm that the farmer is led to bestir himself to suppress it; and yet it is equally true that it is just at this time that Nature is about to relieve him in striking the balance by checks which are violent and effective in proportion to the exceptional increase of and con-

sequent exceptional injury done by the injurious species. Now, the insecticide method of routing this last, under such circumstances, too often involves, also, the destruction of the parasitic and predaceous species, and does more harm than good. This is particularly true of those of our *Coccidæ* and *Aphididæ*, and those of our lepidopterous larvæ, which have numerous natural enemies of their own class, and it not only emphasizes the importance of preventive measures which we are all agreed to urge for other cogent reasons, and which do not to the same extent destroy the parasite; but it affords another explanation of the reason why the fight with insecticides must be kept up year after year, and has little cumulative value.

But the problem of the wise encouragement and employment of the natural enemies of injurious insects in their own class is yet more complicated. The general laws governing the interaction of organisms are such that we can only in very exceptional cases derive benefit by interference with it. The indigenous enemies of an indigenous phytophagous species will, *cæteris paribus*, be better qualified to keep it in check than some newly introduced competitor from a foreign country, and the peculiar circumstances must decide in each case the advisability of the introduction. The multiplication of the foreigner will too often involve the decrease of some indigene. If a certain phytophage is generally disastrous in one section and innocuous in another, by virtue of some particular enemy, it will be safe to transfer and encourage such enemy, and this is particularly true when the phytophage is a foreigner and has been brought over without the enemy which subdues it in its native home. Icerya had some enemies in California, presumably American; but they were not equal to the task of subduing it. Vedalia in the icerya's native home, Australia, was equal to the task, and maintained the same superiority over all others when brought to America. The genus was new to the country, and the species had exceptionally advantageous attributes. But there is very little to be hoped from the miscellaneous introduction of predaceous or parasitic insects for the suppression of a phytophage which they do not suppress in their native home or in the country from which they are brought. The results of the introduction by Mr. A. D. Hopkins of *Clerus formicarius* to contend with the scolytids, which were ruining the West Virginia pines, were doubtful, for the reason that the indigenous species of the genus were already at work in America. Yet the experiment was safe and desirable because the European clerus is more active and more seemingly effective than our indigenes. The gypsy moth was evidently introduced into Massachusetts without its European natural enemies, and as in some parts of Europe it is often locally checked by such natural ene-

mies, a great number of which are known, a proper study of them and the introduction of the most effective could result in no possible harm and might be productive of lasting good.

There are two other laws which it is worth while to consider in this connection. One is, that while a plant-feeder's natural enemies are apt to cause its excessive abundance to be followed by a corresponding decrease, yet this alternation of excessive abundance and excessive scarcity will often be produced irrespective of such natural checks. An injurious insect which has been on the destructive march for a period of years will often come to a sudden halt, and a period of relative and sometimes complete immunity from injury will follow. This may result from climatic conditions, but more often it is a consequence of disease, debility, and want of proper nutrition, which are necessary corollaries of undue multiplication. Frequently, therefore, it may be inaccurate and misleading to attribute the disappearance of a particular injurious species to some parasitic or predaceous species which has been let loose upon it, and nothing but the most accurate observation will determine the truth in such cases. The past year furnished a very graphic illustration in point. Throughout Virginia and West Virginia, where the spruce pines have for some years suffered so severely from the destructive work of *Dendroctonus frontalis*, not a single living specimen of the beetle has been found during the present year. This has been observed by every one who has investigated the subject, and particularly by several correspondents who have written to me: by Mr. E. A. Schwarz, who was commissioned to investigate the facts, and by Mr. Hopkins, who has made the study of the subject a specialty. The clearest explanation of this sudden change is, that the species was practically killed out by the exceptionally severe cold of last winter, since such was the case with several other insects. Now, following so closely on the introduction by Mr. Hopkins of *Clerus formicarius*, how easy it would have been to attribute the sudden decrease to the work of the introduced clerus, had not the decrease been so general and extensive as absolutely to preclude any such possibility! In like manner a certain scale-insect (*Aspidiotus tenebricosus*) had become exceedingly destructive to the soft maples in the city of Washington last year, whereas the present year it is almost entirely killed off, evidently by the same exceptional cold. Many of the affected trees were painted with whitewash, with a view of destroying the aspidiotus, and the death of this last might have been attributed to the treatment (and naturally would be by those employing it) were it not that the same result was equally noticeable on the trees not treated. Reports from southern California would indicate that the red scale (*Aspidiotus aurantii*) is in many orchards losing its destructiveness

through agencies other than its insect enemies, and in this case the facts are particularly interesting, because of the ease with which its disappearance may be attributed to some of the recent introductions from Australia.

The other law that is worth considering in this connection is that, as a rule, the animals and plants of what is known as the "Old" World—i. e., of Europe and Asia—when introduced into North America have shown a greater power of multiplication than the indigenous species, and in a large number of instances have taken the place of the native forms, which have not been able to compete with them in the struggle for existence. This is still more true of the species introduced from the Old World, as well as from America, into Australia, where the advantage of the introduced forms, as compared with the indigenes, has been in many cases still more marked.

There are some instances in which there can be no doubt whatever as to the good which will flow from the introduction of beneficial species, and an illustration is afforded in the caprifig insect (*Blastophaga psenes*). There can be no question as to the good which would result from the introduction of this species from Smyrna into those sections of California where the Smyrna fig is grown without its intervention, and there are other similar instances which promise well and involve no risk. But I have said enough to show that the successful utilization of beneficial insects is by no means a simple matter, and that discriminating knowledge is required to insure success or prevent disaster, especially in the second category dealt with in this paper. The danger attending introductions of beneficial species by unconsciously accompanying them with injurious forms, or by failure to appreciate the facts here set forth, is well illustrated by the introduction to Europe of our *Peronospora viticola*, of the English sparrow to America, and of the mongoose to Jamaica.

Wherever the importance of the matter leads to legislation what are denominated "political" methods are apt either to control or in some way influence the resulting efforts—too often with unfortunate consequences. We should, as economic entomologists, be on the alert for the special cases where the introduction or dissemination of beneficial species promises good results, and do our best to encourage an intelligent public appreciation of such special cases, while discouraging all that is of unscientific or sensational nature, as likely to mislead and ultimately do our profession more harm than good.

SEVENTEENTH-CENTURY ASTROLOGY.

A CURIOUS book is preserved in the National Library of France, the title of which in English would be New Works of Sieur de Conac, Astrologer, Mathematician, Doctor, and Fortune-teller, Advocate of his Majesty. Treating of the Nativity of Men, their Inclination, and what will happen to them through Life. Paris, 1636. But little else is known concerning this Sieur de Conac, except that he wrote a similar book about women. This sage predicts that "the man who is born on Sunday, which is the house of the sun, will be inclined to many callings, offices, and estates, fond of serving the great, and will acquire means according to his quality. If he is noble, he will converse with kings, princes, marquises, barons, and grand lords, and will increase his lordship in quality and make his house illustrious with more grandeur than belongs to it, and his subjects will serve him faithfully; and he will acquire great fame, be subject to headache, toothache, and quartan fever, will be in danger of fire, will travel much, will be lucky in buying horses, and loved by women, and will be married several times; he will not get much from his father, he will be in danger of the plague, and, according to the course of Nature, will live sixty-three years; he will be passionate and sanguine, a little brown and a little red in complexion, and liberal. He will travel much in foreign countries, his secrets will be kept, he will be preserved from his companions and servants, and will make his living by many trades.

"The man born on Monday will have office and authority over the people, will be versed in geometry, arithmetic, and geography. If he is noble, he will receive the rank of king or prince, and will be ambassador, nuncio, or legate; if he is a mechanic, he will be silversmith or goldsmith; if he is in the Church, he will be vicar-general, treasurer, or at least canon; if he is a sailor, he will be captain or master of the ship, pilot or corsair; will be also of phlegmatic nature, subject to catarrhs, will have cross-eyes and toothache, flux, colic, and spleen, swelling of the legs and other parts of the body, and will be hurt in his weak spots. He will be fortunate on the sea, in mills and fisheries, messages, printing offices, most so in agriculture, will be in danger of poison, he will love widows, and will live seventy years. He will be fond of things that come from the water, and will be sculptor, founder, tiller, messenger, or master of fountain and fishes, and will be of fantastic humor.

"The man who is born on Tuesday, his star being Mars, will be hardy, arrogant, threatening everybody, wrathful, a man of good cheer, prompt to attack and ready to meet attack with fire-

arms or other arms, according to the kind of person it is; his vocation will be locksmith, furrier, smith, fabricant of all sorts of firearms; he will be inclined to wantonness, a lover of play, a liar, a swearer, promising one thing and doing another, and will have unrighteous quarrels. In station he may reach the rank of captain, master of the camp, general of the army, chevalier, or Grand Master of Malta, governor of the city, of the castle, or military engineer, mathematician, and on account of his valor will be welcome with princes and lords; will live seventy-two years, and will have only one wife and few children, and will not be in danger of sudden death. He will be a good surgeon, a good anatomist, provost, bowman, sergeant, baker, cook, and violent.

"Wednesday, Mercury's day, promises a man of great mind that he shall be a philosopher, orator, doctor, or astrologer, successful in mechanical practice and arts, as with plants, trees, and merchandise, and may arrive to great dignities, as of ambassador, president, counselor, preacher, orator, good writer, doctor, on good terms with pilgrims, messengers, idlers, vagabonds, counterfeiters, a player with false cards, an adept in occult philosophy, will be wicked with the wicked and good with the good; he will suffer from heart disease, trembling of the limbs, and gouts in the joints; he will have three wives, the change of whom will be good for him; he will have seven or eight children, and will live about fifty years or more. He will be schoolmaster, watchmaker, and instrument maker.

"The star of Jupiter, Thursday, influences a man to great benignity, affability, honesty, discretion, and piety, and to be welcome with princes and kings; he will not be troubled in the courts, and will be rich according to his quality; will be fortunate in marriage, in the service of the prince and great lords, and will reach the quality of nobility or some ecclesiastical dignity; also successful in arms, and with plants, trees, and buildings, minerals, and herbs; and he will profit greatly in voyages, will have a quantity of friends, and will travel in countries where he had no thought of going. If incited by his father or mother, he will have contracts, will be wanton, will have two wives, and many children who will rise in position, and he will live eighty years. He will be a profitable man, liberal, fond of honor, proud, keen, and healthy, affable, jealous of his wives, and will have much knowledge.

"The man who is born on Friday, under the star of Venus, will be by nature very fond of music and of all pleasant things, or will instruct the children of the choir, or will be chapel master, organist, or player of musical instruments, or else a confectioner, glover, perfumer, druggist, or tailor, or something appertaining to

polite exercises; will practice embroidery and other gentle work, will be skilled in making embellishments for women, will marry only once, will have more girls than boys, will love gardens and fragrant things, precious stones, and everything that can adorn the ladies; will be welcome among them, and will live seventy-two years or more. He will be a maker of musical instruments, and a skillful dancer and musician.

"The man who is born on Saturday is apparently solitary, melancholy, and idle, will be glad when his work is done, will suffer in his legs and knees; he will be avaricious, trying to borrow and not return, will go to prison for debts, will be badly dressed for fear of want, and will be subject to rash, gall, and other diseases. In fortune he will have luck in finding treasures, will be rich in inheritances; he will live nearly a hundred years, according to the course of Nature; will addict himself to occult sciences, will be fortunate in solid things like wood, iron, stones, etc., will be fond of many evil things which I will not put down here, there being no need to tell everything. He will be indolent, weak, of bad appearance, lame, poor, ill-formed, if he is not looked upon by the sun or by Venus.

"The whole will be according to the will of God."

Having thus made these wonderful predictions, the Sieur de Conac does not fail to look out for himself, and we read the following little personal item:

"The aforesaid astrologer tells fortunes of the past and the future, reads the disposition of persons in their physiognomy, and sells drugs for the cure of diseases, and has other interesting secrets in his line. The said mathematician lives at Château Gaillard, at the end of the Pont-Neuf, near the Hôtel de Nevers."

This pleasant announcement need not surprise us, for do we not find at the end of this century—this century of progress and light—advertisements in the papers making known to the simple of both sexes that Madame X——, the celebrated cartomancist, predicts the future from the lines of the hand and plays the great game? While the cartomancists of the nineteenth century have their clients, it would be hard to find out why an astrologer should not have had them two centuries and a half ago.—*Translated for The Popular Science Monthly from the Revue Scientifique.*

THE Government of Bengal has been induced to impose additional limitations upon the kinds of cases to which jury trial may be applied. It is alleged that the juries allow personal feelings or caste prejudices to interfere with the discharge of their duty. There is, furthermore, some uncertainty concerning the action of a native jury upon such a charge as forging a receipt for taxes. It is pleaded against this measure that sufficient evidence of the necessity for it has not been adduced, also that it is not prudent to withdraw a privilege once granted and exercised.

SKETCH OF GOTTHILF HEINRICH ERNST MUHLENBERG.

THE late Prof. J. M. Maisch, in his memorial oration on Muhlenberg as a Botanist,* laid stress upon the frequency with which his name is met in works of descriptive botany as that of the person who first recognized as separate and scientifically designated some particular genus or species. Waiving all considerations of credit for priority or of personal fame, the leading aim in all Muhlenberg's botanical work seems to have been to assure the precise and accurate definition of the plant with which he was for the moment dealing.

Names of the Muhlenberg family are conspicuous in the history of this country. Its founder in America, Pastor Heinrich Melchior Mühlenberg, who came to Philadelphia by way of Charleston, S. C., in 1742, was known as the patriarch of the Lutheran Church in the United States. His eldest son, Johann Peter Gabriel, also a minister in his earlier life, was a major general in the Revolutionary War, Vice-President of Pennsylvania, six years a member of the House of Representatives of the United States, a United States Senator, and an officer of the revenue. Another son, Friedrich August, who also began his career in the pulpit, was a member of the Continental Congress, a member and Speaker of the Pennsylvania Legislature, and a member of the House of Representatives of the first four Congresses, during two of which he was Speaker.

The third son, GOTTHILF HEINRICH ERNST MUHLENBERG, the subject of the present sketch, was born in New Providence, Montgomery County, Pa., November 17, 1753, and died in Lancaster, Pa., May 23, 1815. He attended schools in his native place and in Philadelphia, whither his family removed in 1761. When he was ten years old he was sent with his brothers to Halle, in order to finish his academic studies and to prepare for the ministry. Arrived in Holland, the brothers proceeded directly to Halle, while young Henry set out in the care of an attendant for Einbeck, his father's native place, where many of his relatives still lived. Deserted on the journey by the man to whose protection he had been confided, this boy, left without money in a strange land, bravely pushed forward on foot and thus finally reached his destination. After his visit to Einbeck he entered a school in Halle, in which he continued about six years. He spent a longer time

* Delivered before the Pioneerverein of Philadelphia, May 6, 1886, and published in Dr. Fr. Hoffmann's Pharmaceutische Rundschau, June, 1886; also separately. It is the principal source whence we have drawn the matter of this sketch.

in the higher classes than was necessary, awaiting the age at which he could be admitted to the university. This he entered in 1769, but remained in attendance only about a year. He returned to Pennsylvania in 1770, and was ordained by the synod of his church and appointed assistant to his father in the pastoral work "at Philadelphia, Barren Hill, and on the Raritan." In 1774 he was called to be the third preacher in Philadelphia. The prominence of his brothers in the Revolutionary councils exposed him to dangers from the British, as they approached the scene of his labors, and he fled, September 22, 1777, not to return till the following year. In 1780 he became pastor of the Lutheran church at Lancaster, where he spent the rest of his life. Mr. Muhlenberg was married, in 1774, to Catherine, daughter of Philip Hall, of Philadelphia. He had two sons; one them, Henry Augustus, won a high reputation, first as clergyman, and afterward in public affairs. The other son, Frederick Augustus, became an able physician in Lancaster, Pa.

His work in botany began during his residence in the country following his flight from Philadelphia. He resumed the study earnestly after his return to the city, and became deeply interested in the less conspicuous flowering plants and the cryptogams. Botanists had not been idle in the study of North American plants. Even before the time of Linnæus Dr. J. Cornutus had published in Paris, in 1635, his History of Canadian Plants, and John Banister his Virginia Catalogue in London in 1688. Johann Friedrich Gronovius, of Leyden, had brought out his Flora Virginica, with the Linnæan classification, in 1739 to 1743, of which his son published a second edition in 1762. To this work John Clayton, who had permanently settled in Virginia, and whose name is preserved in *Claytonia virginica*—our familiar spring beauty—was a contributor. Other botanists who had worked in this field were Mark Catesby, with his Natural History of Canada, Florida, and the Bahama Islands (1731–1743), and his Hortus Britanniæ Americanus (1763–1767); Julius von Wangenheim, with his German Description of Some North American Trees and Shrubs, with reference to German Forests (1781); Humphry Marshall, with his Arbustrum, or Catalogue of American Trees and Shrubs (1785); and Walter, with his Flora Caroliniana. The works of Linnæus also had much matter of American origin, communicated to him by Peter Kalm, Clayton, John Mitchell, Cadwalader Colden, and John Bartram. Most of these works, and others by the older European botanists, were used by Muhlenberg in his studies.

More strictly contemporary with him were the two Michaux—André (1801–1803) and François André (1805–1813); while in the works of Pursh (1814), Shecut (1806), Le Conte (1811), and Bige-

low (1814) is incorporated matter borrowed from the results of his researches.

It thus appears that the field of the present Atlantic Middle States had been explored with considerable energy before Muhlenberg's time. New species of plants had been discovered and additional information had been gained concerning species already known. The scientific value of these observations, attested by the herbariums which still exist, and by what Muhlenberg furnished for publication, is enhanced and interest is added to them by a careful perusal of Muhlenberg's correspondence, a part of which he kept and is now preserved by the Historical Society of Pennsylvania. These letters—some from European naturalists and others from American—were written in the last sixteen years of the eighteenth century and the first and part of the second decades of the nineteenth, and are often annotated with Muhlenberg's remarks. Of his own letters only a few copies are present, chiefly those which he wrote between 1791 and 1794 to Dr. Manasseh Cutler, of Ipswich, Mass. Further, a number of letters from various students and note-books, botanical notices, descriptions, and outlines in Muhlenberg's handwriting are in the possession of his descendants, or have been handed over by them to scientific societies.

The note-books bear witness to the earnestness with which Muhlenberg took up and pursued his botanical studies after his flight from Philadelphia. During the year 1778 may be found numerous descriptions of plants like that of *Eupatorium purpureum*, trumpetseed or gravel root; to which are added such notes as "is probably *Eupatorium* (*altissimum*)." Doubtful remarks of the kind abound. "Is it probably *Actea?*" "It may be *Azalea?*" "Perhaps it is *Convallaria?*" It is evident from such notes that Muhlenberg had not advanced far in acquaintance with the wild plants in the summer of 1778. In the same year he seems to have drawn up a plan of studies by the systematic execution of which he could hardly fail to acquire the desired knowledge. Its most notable points are as follows: "How may I best advance myself in the knowledge of plants? It is winter, and there is little to do. In winter I must select such plants as I can easily remove. . . . Toward spring I should go out and form a chronology of the trees, how they come out, and of the flowers, how they appear, one after another. . . . I should especially remark the flowers and fruit; and there are many other circumstances, but none quite so essential.

"1. The flower, the time, the part of the plant it stands on, whether there are stamens, and how many; the pollen; whether there are pistils, and how many; their shape; whether and how there is a corolla; its color and shape; whether and how there is a calyx.

"2. What sort of a seed, and what kind of a fruit.

"3. How the plant appears otherwise; its root; its stem, if it has any; and its leaves.

"4. To make remarks on the occasional peculiarities of the plant; of my own on the smell, taste, etc., and of what others say, of which one story in a hundred may be true.

"If I could make an herbarium in whole or in part, it would be so much the better. I might plant the more important specimens in my garden. A good friend, who has the knowledge and the disposition to help me, would be of great advantage (Mr. Young, three miles from here).

"Materials to be taken on excursions: An inkstand, with pen and paper, and a box to carry my plants in safely. And when possible, a microscope. Besides the box a few sheets of paper stitched together in folio, in which to lay the plants and carry them; to be tied up in front."

It was not long before Muhlenberg became engaged in correspondence with other botanists. Dr. Johann David Schöpf, an officer of the Hessian troops stationed in New York during the Revolutionary War, who traveled through the Eastern States to Florida, after the conclusion of peace, in search of medicinal plants, became acquainted with Muhlenberg and was assisted by him. After his return to Germany he was the occasion of a correspondence between Muhlenberg and Prof. Schreber, of Erlangen, and this was followed by exchanges of letters with other eminent botanists in Germany, England, France, and Sweden, as well as with Americans.

Like a true naturalist, Muhlenberg continued to exercise the greatest care and thoroughness in observation and research. A botanical excursion and note book of 1785 contains the following plan of work:

"This year I shall again keep a calendar of all plants as I may observe them, especially when in bloom. When I am quite certain, I shall set down only the Linnæan name; when not quite certain, I shall make a full description. Especially shall I try to complete the descriptions of 1789 in those kinds of plants in which many species are most exact. As I very carefully explored this region last year, I shall this year visit other regions, namely: 1. The mountains on the Susquehanna, in May and July. 2. The mountains called Chestnut Mountains, also twice, etc. I must further call upon apothecaries and take other pains to learn the officinal plants, their virtues and their common names. I must this year pay particular attention to the seeds, and especially to describe all herbs as completely and exactly as possible, especially when I am not wholly certain. I shall give particular attention to those of which there are many species, such as asclepias, con-

volvulus, serratula, aster, solidago, and all the ferns. . . . The seed vessels and seeds are very important for the genus and species, and I must therefore give careful attention to them." He also indicates here as one of his purposes, besides the native plants, to observe all the exotics, whether they need protection in winter or are completely acclimated.

In the spring of 1791 he was able to inform Dr. Cutler that he had collected more than eleven hundred different plants in a circuit of about three miles from Lancaster, and that he was devoting himself to the collection of material concerning their medicinal and economical applications. In a later letter, November 8, 1791, he wrote: "I am collecting, as far as possible, all I can learn concerning the medicinal and economical uses of our plants and am writing it down. If the medicinal application seems to be sufficiently confirmed from different sides, and agrees with the character of the plant, I either try it on myself or commend it to my friends. I raise most of the grasses in my garden, and experiment how often they can be cut, and whether they are readily eaten by horses or cattle." These grasses numbered at the beginning of 1798 one hundred and fifty-six species, including many introduced ones, and among them were a large number of new species and at least one new genus. This collecting and testing of grasses is mentioned in other letters. An exchange seems to have been arranged with Prof. Schreber, of American plants for foreign grasses; and, besides mosses, grasses of New England were obtained from Dr. Cutler, especially such as grew near the sea.

Some of these notes on the medicinal properties of plants, Muhlenberg says, were furnished to Dr. Schöpf for use in his contemplated work on American *Materia Medica*. Although the author of that work, which was published in 1787, acknowledged indebtedness for information to several other American botanists, he does not give Muhlenberg's name—a most ungrateful omission. A similar case occurred in connection with an American book. When Muhlenberg first saw a copy of Bigelow's Medical Botany, he could not help remarking to his son, after looking through it, "This gentleman has appropriated to himself all my explanations, without making any acknowledgment." But he never called public attention to this, and there were other such trespasses which were also let pass unnoticed.

In July, 1785, Muhlenberg communicated to the American Philosophical Society an outline of a *Flora Lancastriensis* (flora of Lancaster) containing the results of his own observations on the plants and their habits. At the same time he presented a manuscript Calendar of Flowers. In February, 1791, he communicated the *Index Flora Lancastriensis* (Index to the Flora of Lancaster). This was published in the third volume of the first

series of the Transactions of the society. It is arranged according to the Linnæan system and contains four hundred and fifty-four genera with nearly eleven hundred species, including both wild and cultivated plants. Of the naming of these plants, Muhlenberg remarked in a note: "When I found no name in Linnæus's system, I took a name from other recently published works, or from the letters of Dr. Schreber, with whom I kept up a correspondence. When I found no name in this way, I was obliged to give one myself and to add to it N. S., till better information came from more capable botanists." The cryptogamous plants are represented in this index by twenty-five genera with one hundred and twenty-five species. The work, as its name implies, consists merely of the enumeration of the species observed, without description or indication of their habits or uses. A supplement to this index, presented to the American Philosophical Society in September, 1796, and published in the fourth volume of its Transactions, contained forty-four additional genera with sixty-two species of phanerogams, of which nine were hitherto unknown species of grasses; while the cryptogams were further represented by two hundred and twenty-six additional species, belonging to twenty-nine genera.

Muhlenberg perceived very early in his botanical studies how great confusion was likely to arise if names were conferred upon plants supposed to be new, without considering whether they might not have been previously identified and named by others. We have already described the painstaking care he took in his own notes to find the correct names of his specimens. While he was critical of the work of others, he was always ready to recognize their merit, and to make allowance for their imperfections. He wrote to Dr. Cutler of his work on the Useful Plants of New England that, although the author regarded it as immature, "it was of great use to me, and I was very much pleased with it. Every beginning will be imperfect, especially in a new country, and I have not yet read any botanical work without errors. Even Linnæus's works, which were prepared with so much industry, are full of them." In another place he wrote: "Herr Aiton,* in my opinion, makes too many species out of varieties; for instance, his asters and goldenrods. We must expect such things when descriptions are made from specimens taken from a garden instead of from their natural habitats, where plants grow numerously and in various soils." Other criticisms of similar tenor may be taken from his letters, all made from the point of view of exactness in identification and description.

Freedom from self-glorification and from solicitude for the

* In his Hortus Kewensis, 1789.

recognition of his work are patent in all his writings and transactions. When Dr. Barton announced, in 1791, his illustrated Flora of Pennsylvania as in preparation, Muhlenberg concluded that as that author had seen his manuscripts and herbarium, it would not be necessary for him to publish anything except a few additional notes which he might make during the year, and a Floral Calendar. "Excuse my enthusiasm for science," he wrote to Dr. Cutler, in 1792, "which has given me so many pleasant hours, and which, I know, has been cultivated by you with great success. Botany needs your co-operation, and when you have prepared a full table, please leave a few fragments for me." It was this readiness to give credit to the merit of others, combined with his clear vision of the confusion that threatened to arise from the continuance of planless labors, that decided him as early as 1785 to bring out a plan for common labor in making up the Flora of North America. He came to the Philosophical Society again in 1790 or 1791 with this plan. "I repeat," he writes, "my formerly expressed desire that a number of my learned countrymen should unite in botanical investigation and send in their floras to the society for revision and publication, so that by combination of the floras of the different States we may obtain a flora of the United States which shall rest on good and definite observations." While this plan was not carried into execution through the medium of the American Philosophical Society, Muhlenberg again and again returned to it in his extensive correspondence. Thus he wrote: "Others should do the same (that is, search out the flora of the neighborhood of their homes), and, after collecting material for a dozen years, let a Flora of North America be written." Further, "I first sent in a sketch, and in 1790 an index of all the plants that grow here, in the expectation that my botanical friends would join in working up the floras of their several States, so that in about ten years a more general work might be undertaken." And in another place: "If the botanists continue to proceed in the way they are going, in a few years all will be confusion. In order to be sure, we should confer with one another. For this purpose I have printed my Index before publishing full descriptions." A letter to Dr. Cutler, of November 12, 1792, goes more into particulars; it reads: "You have made the beginning of a Flora of New England, and all friends of botany wish that you would go on and complete the work. Let each of our American botanists do something, and the wealth of America would soon be recognized. Michaux should do South Carolina and Georgia; Kromsch, North Carolina; Greenway, Virginia and Maryland; Barton, New Jersey, Delaware, and the lower parts of Pennsylvania; Bartram, Marshall, and Muhlenberg, each his neighborhood; Mitchell, New York; and you, with the Northern botanists, your States. How

much might then be accomplished. If, then, one of our younger associates—Dr. Barton, for instance, whose specialty it is—would combine the different floras into one, how pleasant it would be for the botanical world! I have written to nearly all the persons named above, and hope to receive their concurrence. Let me know your views about it." Dr. Cutler gave the scheme his unreserved approval.

This plan was not carried out. Instead of it, André Michaux worked the combined collections of his eleven years' travels in the United States, through the French botanist Richard, into a Flora of North America, and it appeared in Paris in 1803, one year after the author's death in Madagascar.

The publication of this flora did not change Muhlenberg's view of the necessity of comparative work in co-operation, and in order to bring it a step nearer he decided in 1809 to write a catalogue of the then known native and naturalized plants of North America (*Catalogus Plantarum Americæ Septentrionalis, huc usque cognitarum indigenarum et cicurum*), the printing of which was finished after nearly nine months of work, at the end of July, 1813. While Michaux had described about fifteen hundred flowering plants and ferns, Muhlenberg was able ten years later to exhibit more than double the number of species, and besides these to add, from specimens mostly collected in Pennsylvania, 175 mosses, 39 liverworts, 32 algæ, 176 lichens, and 305 fungi, in all 727 species. The *Compositæ* comprised in Michaux 193 species, in Muhlenberg 410.

Muhlenberg conscientiously named not only the books which he had used in the determination of his collected plants, but also the twenty-eight correspondents in different parts of the United States who had assisted him in his researches by sending plants or seeds. The work gives, besides the botanical and English names, only the numbers of the several parts of the flower, the color of the corolla, the character of the fruit, the locality, and the time of flowering, all as briefly as possible.

At the same time a complete description of the plants growing around Lancaster had been ready to print for years; likewise a complete description of all the other North American plants which Muhlenberg had himself seen and arranged in his herbarium. These descriptions were consequently based entirely on his own knowledge, and had, therefore, especial value. Unfortunately, they have not been published.

A part of one of these works, comprising the grasses, was printed in 1817, two years after the author's death, under the title *Descriptio uberior Graminum* (Fuller Description of Grasses). The manuscript of it was presented by Zaccheus Collins, a friend of Muhlenberg, to the American Philosophical Society in 1831.

The valuable herbarium, for which Muhlenberg collected and sorted for a full third of a century, was bought by a number of his friends for a little more than five hundred dollars, and was presented to the American Philosophical Society in February, 1818. It was then in good condition, but has, unfortunately, not been well taken care of, and has become so decayed as to have little if any more than historical value.

In considering the question of the value to science of these labors of a whole lifetime, we should think first of the greater clearness which resulted from them to the descriptive botany of North America. Although Muhlenberg printed but little, and although he often lost the claim to priority through being anticipated in publication by less reserved botanists, yet we find in Gray's Manual of the Botany of the Northern United States about one hundred species and varieties which were first established as such by him, and besides them a nearly equal number which were either assigned afterward to other genera, or with which, on the principle of priority in publication, the names given by other botanists were retained. This is really an admirable result, considering the zeal of collectors and hunters before and during Muhlenberg's time, and the limited extent of the field which he was able personally to examine. His services have also been well recognized by botanists. A goldenrod was given by Torrey and Gray the name *Solidago Muhlenbergii;* Grisebach named a centaury *Erythræa Muhlenbergii;* a small willow was called by Barratt *Salix Muhlenbergii;* and Gray gave the name *Muhlenbergii* to a species of reed or sedge. Two mosses of the genera *Phascum* and *Funaria* were named after Muhlenberg by Schwartz; two lichens of the genera *Umbilicaria* and *Gyrophora* by Acharius; and a fungus of the genus *Dothidea* by Elliott.

About half of the plant names given by Muhlenberg which are now recognized belong to the reeds and the grasses, *Cyperaceæ* and *Gramineæ*, in the study of which he was supported by Schreber. One of the first new genera of grasses observed by him, to which belong seven species in the Northern floral region of the United States, and a still larger number of other species in the other States and Territories, was given the name *Muhlenbergia* by Schreber. At least five species of this genus, which have not become domiciled east of the Mississippi, are known in Colorado.

This review of Muhlenberg's botanical work would not be complete without special mention of his scientific correspondence, his personal intercourse with naturalists, and the honors he received. Among his foreign correspondents were Dillenius, Hedwig, Hoffmann, Persoon, Pursh, Smith, Schöpf, Schreber, Sturm, Willdenow, William Aiton, of Kew; Batsch, the mycologist; Palisot de Beauvoir in Paris, and Dr. Thibaud in Montpellier; Christian

Ludwig Schkuhr, of Wittenberg, an eminent cryptogamist; Professor and Medical Counselor Heinrich Adolph Schrader, of Göttingen; Kurt Sprengel, professor of medicine and botanist at Halle; and Prof. Olof Swartz, one of Linnæus's most eminent pupils. Among the twenty-eight home correspondents mentioned by Muhlenberg in the preface to his catalogue are the Rev. Christian Denke, of Nazareth, Pa., the Rev. Samuel Kramph, of North Carolina, the Moravian bishop Jacob Van Vleck, and Dr. Christopher Müller, of Harmony, Pa. One of the most valued was Dr. Baldwin, of South Carolina, and Muhlenberg's letters to him have been published by William Darlington, in a volume entitled Baldwiniana. All or nearly all these correspondents were entertained by him in his home at Lancaster, which was open to all students of plants, and was usually visited by them when they came to Philadelphia. Alexander von Humboldt and Aimé Bonpland sought him there on their return from their long sojourn in Spanish America; and Humboldt's letter acknowledging his hospitality is the last which that master in science wrote in America.

Learned societies and institutions likewise covered him with their honors. The University of Pennsylvania gave him the degree of Master of Arts in 1780; Princeton College, that of Doctor of Divinity in 1787. He was elected a member of the American Philosophical Society on January 22, 1785, along with Joseph Priestley and James Madison. Of other societies he received diplomas: from the Imperial Academy of Erlangen, 1791; the Society of Friends of Natural History, Berlin, 1798; the Westphalian Natural History Society, 1798; the Phytographic Society of Göttingen, 1802; the Physical Society of Göttingen, 1802; the Linnæan Society of Philadelphia, 1809; the Academy of Natural Sciences of Philadelphia, 1814; the Society for the Promotion of the Useful Arts, Albany, N. Y., 1815; the Physiographical Society of Lund, Sweden, 1815; and the New York Historical Society, April 12, 1815, not quite six weeks before his death.

Introducing the description of a *Muhlenbergia* in the second volume of his work on the Grasses, Prof. Schreber wrote: "The genus of which this remarkable grass is on account of its beauty and of the particularly curious structure of its organs of fructification one of the most notable species, received its name from me when I published the new edition of the *Genera Plantarum* of the honored Linnæus, after my most revered friend Dr. Heinrich Muhlenberg, evangelical preacher at Lancaster, Pennsylvania, and President of Franklin College there, and also an eminent member of many learned societies; who has, through the discovery of numerous new species and in other ways, rendered immortal service to the natural history of North America, and especially to the knowledge of the plants of Pennsylvania and the other United States."

CORRESPONDENCE.

ARTIFICIAL STIMULATION OF TRUSTS.

Editor Popular Science Monthly:

SIR: On reading Mr. McPherson's paper in your July number, and in view of the present strike, I am more than ever impressed with the social importance of the central idea which I endeavored to set forth in a paper, Corporations and Trusts, sent for your consideration last winter. At this time I desire to call your attention to what seems to me to be an entirely unwarrantable position assumed by Mr. McPherson.

After showing that there is a general tendency toward specialization by the evolutionary working of natural laws, he *assumes* that it has been and is wise to still further specialize by formation of corporations and trusts—that is, by artificial means. On page 296 he says, "This industrial aggregation is a natural and inevitable step of industrial evolution that therefore can not be but beneficial in its final results." *So far as the aggregation is the result of natural laws*, not statutory laws, this may be so; but to the natural aggregation, with the hardships and advantages incident thereto, there has all along been an *unnatural* aggregating power at work. I refer to the laws permitting the formation of corporations for business purposes. I hold that natural processes weed out the weak and unfitted fast enough and with sufficient attendant pain and contention. Natural aggregation and natural competition may be well, and their results on the whole are probably beneficial; but citing facts in proof of these things, or calling our attention to evolutionary doctrines of what natural laws have accomplished, does not even tend to prove that legislative enactments help to produce a beneficial aggregation or specialization. The sociological part of evolution comes pretty near establishing that *all* such enactments are of very doubtful propriety. That the law permitting the formation of corporations for business purposes has been more productive of bad than good results seems to me very probable, and that therefore it is *relatively wrong*, and never intended, *on the whole*, to produce "beneficial results," or "aggregations" that *were beneficial*.

Mr. McPherson certainly fails to show any such beneficial results and proofs thereof. The fact is that natural laws are exact, and the pain and pleasure or both are commensurate, exact, and just, and tend to work beneficially on the whole; whereas any and all legal enactments are more or less *inexact*, and no *such perfect degree of justice, pain, and pleasure follows;* frequently what follows *is almost wholly injustice.*

For the great mass of people to accommodate themselves to this "aggregation" as fast as natural laws would force it is to tax them to their utmost limit of endurance; but when we artificially stimulate this "aggregation" we have passed beyond their power or ability to maintain their peace, and strikes, bloodshed, and untold misery are among the results. Much, if not all, of this open contention and misery would be avoided if only the natural aggregating causes produced effects. It is the *artificial* "aggregating" force of corporations that has so overloaded the national stomach with its "aggregations," combines, and trusts; and now that stomach is in violent upheaval, trying to free itself.

Free competition is well, and so are laws preserving it in peace; but laws which assume to be able to help *natural processes* are and always have been relatively bad, and in some instances very bad.

If legislation permitting the formation of private or business corporations *has increased the aggregating process* and contributed to (or produced) the cause of trusts and strikes—and Mr. McPherson seems to grant that it has, which is just what I attempted to show, among other things, in my paper—then such legislation is something the afflicted classes have just cause to complain of.

The great importance of the question, and the suffering and the pending crisis, are my excuses for calling your attention a second time to this matter; and, also, as I believe, when recognized, errors are not allowed to go uncorrected in your monthly.

I remain very truly yours,

CHARLES WHEDON.

MEDINA, N. Y., *July* 10, 1894.

EDITOR'S TABLE.

SOCIAL DISTURBANCES.

THE events of the last few months in this country have certainly been enough to rouse the most indifferent citizen to serious reflection. In an already depressed condition of industry and commerce we have had thousands of men condemned by arbitrary action to wholly unnecessary idleness, trade in certain sections of the country all but paralyzed by the interruption of communication, and property to the value of millions of dollars destroyed. As an accompaniment to all this there has been considerable loss of life through violence; and the heated passions of men have not stopped short even of the most hideous and diabolical crime of train-wrecking. What further developments the future may have in store for us it is impossible to say; but it is hard to feel hopeful over the prospect unless the public can be got to look a little more deeply into the causes of these troubles than hitherto they have been accustomed to do.

It seems to us that the prevalent habit of regarding such disturbances as arising entirely out of a strained relation between capital and labor is an unfortunate one. Still more unfortunate is it, and still wider of the mark, when emotional people attribute all such troubles to the tyranny of capital. If capital were at all times to give way to the demands of labor, capital would cease to exist, and, population having meanwhile increased in a more than ordinary ratio, general social penury would be the result. Capital may be said, without much abuse of metaphor, to have the same instinct of self-preservation that organic beings have: it will fight for its life. To many people the sight of a capitalist withstanding the demands of his workmen suggests nothing but inordinate selfishness and greed; but this is not the capitalist's view of it; what he feels—we are now supposing a typical case—is that he can not meet those demands without unduly weakening himself and putting his men in the position of getting more than the market value for their labor. We do not say, and are very far from thinking, that capitalists never do selfish things. Still less do we say, or think, that they rise, as a rule, to the level of their social responsibilities; but we wish to affirm our opinion that capital is perfectly justified in acting on that instinct of self-preservation already referred to, seeing that it is a strictly limited quantity and can not without risk of extinction take upon itself the burden of satisfying the ever-expanding desires of mankind. Human desires are like a gas whose volume varies inversely with the pressure to which it is subjected, or, to state it otherwise, which expands just as the pressure acting on it is reduced; and to suppose that one set of men should be able by successive concessions to keep another much more numerous set of men continually satisfied is to suppose what in the very nature of the case is absurd.

Instead of perpetually canvassing the supposed rival claims of capital and labor it would be better if our social reformers would apply themselves to the underlying question how it comes that there is so much competition among the so-called laboring classes for the kind of employment which capitalists supply. The capitalists themselves do not create the competition. If they yielded to all the demands made upon them in the matter of wages and hours, they might be said to do, because then they would be creating conditions which would have a tendency to cause men to rush

into their service. But they do nothing of the kind: as a rule they only yield when they have to, and yet there is generally more labor offering than can be satisfactorily employed. Now, this we consider to be the fundamental social problem of our time; and yet we do not find that it receives anything like the attention it deserves and requires. The labor organizations which play so prominent a part in the modern world seem to assume that labor will always be in excess, and devote their chief efforts to neutralizing by artificial means this natural disadvantage. Their attitude toward capital is thus normally a hostile one, even when actual hostilities are not in progress; and this fact alone may account for not a little of the friction which actually occurs in the practical relations between capital and labor. To be always confronted with a hostile force is not soothing to the temper, and suggests at least defensive, when it does not suggest offensive, measures. It would be better, as it seems to us, if the labor organizations would cultivate less of the militant and more of the administrative spirit, and would use the wide knowledge they must necessarily acquire of the conditions of the industrial world to prevent the overcrowding of particular trades, and, in a general way, to favor such a distribution of the working population as will tend most to their welfare. As long as the capitalist has only to blow his whistle, so to speak, in order to get all the "hands" he requires, the condition of the "hands" will be one of more or less dependence on him; and therefore the true policy of labor leaders is to try to so dispose of the laboring population that they will not be at the beck and call of capital, but will have a much larger measure than at present of social stability and personal independence.

Just how this very desirable result is to be brought about we are not prepared to say; but what strikes us is that if more effort and thought had been devoted by the working classes, organized as they are in unions which permit of their best men coming to the front, to problems of a constructive character, and less to the planning of campaigns and the devising of means by which the least return in labor should be given for the largest obtainable wage, they would have been the better of it to-day. One thing which they should long ago have seen is the desirableness of their complete separation from mere party politics, which, so far as they are concerned, is a simple delusion and a snare. What the workman wants is the simplest and cheapest form of government, and, above all, one under which no exceptional favors will be accorded to individuals or classes. If he is not wise enough to see this, but falls a victim to the special pleading used on behalf of preposterous tariff laws, he can not lay the blame on others; what he wants is understanding, and, until he gets it, he will suffer. A generally higher ideal of life would stand the workman in good stead—an ideal opposed to show and extravagance and favorable to earnest endeavor for intellectual and moral improvement. We are no advocates for "starvation wages"—far from it—but we can not overlook the fact that what one individual considers starvation wages will sometimes suffice for the comfort and self-respect of another, the difference between the two cases being one of personal habit.

As to the capitalist class, there is this to be said, that the man of large means, the large employer of labor who does not interest himself in his men and make the conditions of their labor as profitable and satisfactory to them as possible consistently with a due regard to the stability of his business, is shamefully neglecting the duties which lie to his hand. We have but a limited belief in what is commonly known as philanthropy, but we believe in justice and good will between man and man, and it should not be hard for the capitalist to

determine whether he is doing by those under him as, were he in their position, he would wish, and might reasonably ask, to be done by. This is an age in which luxury runs wild. The capitalist may fairly treat himself liberally; but if he has the true spirit of humanity about him, he will not make of himself a demigod or raise himself to Olympian heights above the people. In saying this we may be as the voice of one crying in the wilderness; but if a message has to be delivered, it is better to cry out in the wilderness than not to cry out at all. Socialism as a system of government fills us with the most profound apprehensions; but, on the other hand, there is a certain socialism of the heart, if we may so express it, which we would gladly do all in our power to encourage—that feeling which leads a man, be his station what it may, to consider that he lives not for himself alone, but for the good of society at large. There is much said about the duties of the rich, but it is doing the rich too much honor to speak and write as if they alone had social duties. The welfare of society depends in the main on the good citizenship of the multitude, and not on anything the rich have it in their power to do. To them also it is given to be good citizens; but the call is not more imperative to them than to those of average or scanty means. It is an old, and ought to be an exploded, fallacy that a single talent is not worth improving. The social millennium will come, if ever, when all the single talents are being improved with a distinct, even if only secondary, aim to the common good.

ENDOWMENT OF RESEARCH.

A RECENT number of Nature contains an article which begins by lamenting the neglect of the British Government to make any adequate provision for the carrying on of physical and chemical research, and then goes on to state that a wealthy manufacturer of high scientific culture, Dr. Ludwig Mond, had purchased for the Royal Institution a spacious building in which to establish physical and chemical laboratories of the most approved kind, and had undertaken to defray all expenses connected with the equipment and maintenance thereof. Now, it seems to us that Dr. Ludwig Mond's action in this matter is highly commendable, and that the action of the British Government in leaving the establishment of such laboratories to private enterprise and beneficence is also commendable. It should never be forgotten that whatever money the Government spends comes from taxation, and that the taxes are levied in great part from the poor. Whether, then, is it better that the Government should spend the proceeds of taxation on such objects as these, or that intelligent and cultivated men like Dr. Ludwig Mond, who have amassed great wealth by the exercise of their talents, should come forward and undertake the duty? We say without hesitation that the latter is far the better solution of the question. If the Government were to do everything of this kind, one of the noblest uses to which private wealth can be put would be at an end. Not only so, but wealthy men would no longer have any interest in studying the needs of the community, and would be left even more than they are at present to indulgence in luxury as the one means of expressing the fact that they are wealthy. If we want to redeem our rich men from the vanity, inanity, and vulgarity of self-indulgence and ostentation, the way to do it is for public opinion to assign them social tasks suited to their means and opportunities; and this can not be done if the Government is asked to shoulder all such responsibilities. All honor to men like Ludwig Mond, who, without any special urging, see what is required for the public good and do it! In this case high intelligence goes hand in hand with

command of pecuniary means; and there is, therefore, reason to believe that what is done under his direction will be well done, and will not be marred or weakened by the perfunctory spirit which so often accompanies state action.

LITERARY NOTICES.

FACTORS IN AMERICAN CIVILIZATION. Popular Lectures and Discussions before the Brooklyn Ethical Association. New York: D. Appleton & Co. Pp. 417. Price, $2.

THIS volume, the third in the series issued by the Brooklyn Ethical Association, certainly does not fall below its predecessors in interest or the range of its topics. Five of the addresses relate to national life; two lectures are devoted respectively to commerce, the status of woman, and the labor question; while the subjects considered in the remaining three papers are sufficiently diverse—penal methods, charitable work, and the drink habit.

Beginning with the idea of the nation, Dr. De Garmo finds it to be the ultimate unit in civilization. We advance by helping each nation to unhampered development upon its own lines, not by breaking down national barriers. The discussion discloses that Mr. Spencer's idea of government is often misapprehended, especially when drawn from old editions of Social Statics. Our American civilization is, however, the product of numerous factors. The first of these in time, those furnished by Nature, are described by Rev. John Kimball, who agrees with Prof. Shaler that even the boundaries of the civil war may have been determined by the distribution of the Cretacean limestone.

What America owes to the Old World is epitomized by Mr. Palmer as everything except itself. From England we inherit our language, literature, trial by jury, and various institutions; from the Netherlands, our cherished ideas of religious tolerance, popular education, and the freedom of the press. The written ballot is due to the same source, the town meeting is Germanic in its origin; while to Spain, France, and continental Europe we are indebted in other matters.

Dr. Janes shows what the military habit costs us, contrasts the warlike and industrial type, and leads us to question whether the cultivation of the militant spirit pays. Mr. Robert Taylor discourses upon the evolution of railways and illustrates the great progress made in transportation. To move the freight of the United States in 1892 would have required five times the working force of the world one thousand years ago. Foreign commerce is ably handled by Mr. Coombs, and is followed by the inevitable discussion between the advocates of free trade and protection.

An eloquent plea for the political equality of woman is made by Rev. Mr. Chadwick, who remarks that if the objections to woman suffrage could be shut up together by themselves they would dispose of each other. Interesting statistics and suggestions in regard to the economic position of woman are also given by Caroline B. Le Row. Those interested in charities will find a comprehensive paper on the subject by Dr. Warner. Elsewhere in the volume, in an essay upon labor, Mr. Sullivan demands justice instead of charity. From another standpoint Mr. Gilman deals very fairly with the labor question, and without "preaching profit-sharing as a panacea for industrial woes" still recommends it as an improvement upon the wages system. A review of penal methods and institutions is contributed by Mr. McKeen, and an investigation of the drink habit by Dr. Crothers. Finally, philosophizing upon history, Mr. Powell concludes the book.

The discussions following the lectures and the lists of collateral readings suggested contribute much to the value of the work.

THE YACHTS AND YACHTSMEN OF AMERICA: A STANDARD WORK OF REFERENCE. HENRY A. MOTT, Editor. New York: International Yacht Publishing Company. Vol. I. Pp. 692, with Eighty-nine Plates. Price, $15.

THIS sumptuous work is further defined on the title-page as A History of Yachting and of Yacht Clubs, as well as of the Various Yachts, with Biographies of the Founders and Members of the Different Clubs of the United States and Canada. Yachtsmen of all clubs have long desired to have a work for ready reference, which, besides reliable information relative to the yachts belonging to members of their respective clubs, would give facts

relative to the yachts and yachtsmen of other clubs. The purpose of this book is to supply such information, and in addition to furnish portraits and biographical sketches of persons who have been and are prominently connected with yachting, and of those who have been instrumental in promoting the best interests of yachting, as well as illustrations of the various yachts, with descriptions of the same, their dimensions, capacities, and records. A history is given of each yacht club separately, with a statement of what has been done by its members in promoting the sport of yachting. In the first chapter the evolution of the yacht is described from the beginning with the first presumed attempt of the stone-age savage to propel himself upon a log, through the stages of the catamaran, the hollowed log, the dugout, the birch-bark canoe, the more elaborate canoes of the South Seas and the Indian Ocean, Egyptian, classical, and Viking ships, and the stages of modern shipbuilding to the elaboration of the pleasure boat or yacht of to-day. The history of yachting is next given. Leaving out the ships of Amnon in Jacob's time and the Argonauts' ship Argo, which were business vessels, the first yachts proper on record appear to have been those of Ptolemy Philopater of Egypt and Hiero King of Syracuse. After twelve of the broad quarto pages of the book on the history in general, twenty similar pages are devoted to yachting in the United States. Then follow chapters on the Cost of Yachting and Yacht Decorations; Type of Yacht; Centerboard; Rig of Yachts; Speed Records of Sailing Yachts; Trophies; History; Record of Races; descriptions of yachts and biographical sketches of members of the five leading Canadian yacht clubs, and similar information relative to thirty-eight yacht clubs in the United States. The volume contains more than six hundred photo-etchings of yachts and clubhouses, nearly two hundred half-tone vignettes of yachtsmen, more than forty full-page half-tone portraits of commodores, and a hundred full-page photogravures of yachts and clubhouses. A second volume is to contain a leading chapter relative to the introduction of steam on yachts and to various other motor powers; a history of the America's Cup; histories of such yacht clubs as do not appear in the first volume; and photogravures and descriptions of the vessels, cruisers, and war ships of the American Navy.

NATURAL THEOLOGY. By Prof. Sir G. G. STOKES. London: Adam and Charles Black. Pp. 272. Price, $1.50.

THE second course of Gifford Lectures is contained in this volume, the first series of which was delivered and published in 1891.

According to the will of the founder, the subject was to be treated as a strictly natural science, without reference to or reliance upon any supposed exceptional or so-called miraculous revelation.

Prof. Stokes has made no attempt to fulfill this requisition, stating at the close of the course that the conception is hardly possible to carry out in the manner contemplated, and elsewhere that "any divorce between natural theology and revealed religion is to be deprecated." He justifies his deviation from the plan partly by an appeal to another clause in the foundation, suggesting that the lectures should be promoted and illustrated by different minds.

There are ten addresses in all, the first six giving what arguments are offered in favor of theism. The first topic is the theory of the luminiferous ether and the character of the proof for its credibility, a lesson being drawn from this not to reject what transcends sense experience and to provide a favorable reception for the supernatural. Secondly, it is argued, as the simple laws of motion did not account for inorganic phenomena, but to them were added various theories from time to time, such as gravitation and magnetism, so we are justified in assuming some hypothesis for the construction of living matter which physical laws do not fully explain: this is named the theory of directionism. If also this individual directing power be supposed, by whose influence the bodily molecules are brought together, we obtain some notion of survival after death, since it is not subject to physical dissolution.

The exquisite construction of the "bacillary layer" of the retina and the beauty of color and marking found in plants and animals are adduced as evidences of design, and the laws of chemical combination as testifying to some scheme of creation including the

welfare of man. The "vast array of primordial atoms" as well as the beginning of life upon the earth demand the exertion of creative power; this, it is claimed, or even subsequent creative acts, are not in conflict with the process of evolution.

In the remaining lectures the author does not enter upon a comparative study of religions, but confines himself to the claims of Christianity.

Whatever may be said in favor of the theistic arguments contained in the first part of the book can scarcely be maintained in regard to these deductions, wherein it is urged that the Christian doctrine of the origin of man, his fall from a state of innocence, the dogma of the Trinity, and the indwelling of the Spirit "satisfy certain aspirations of natural theology."

THE DAWN OF ASTRONOMY. By J. NORMAN LOCKYER, F. R. S., etc. New York and London: Macmillan & Co. Pp. 432. Price, $5.

IT would be impossible to determine whether the heavenly bodies aroused the greater wonder in the ancients, who could know but little of their real nature, or in us, who have learned something of their immense sizes, distances from the earth, and velocities of motion. That the ancients were profoundly impressed by them, and were attentive observers of their phenomena, is being made more and more evident by the advance of archæological research. While in Greece, some four years ago, Prof. Lockyer became interested in determining the orientation of some of the Athenian temples. He found reason to believe that these structures were oriented upon an astronomical basis, and, carrying the investigation back to the works of the ancient Egyptians, discovered the abundant evidence in support of his supposition which is embodied in the handsome volume before us. The great temple of Amen-Ra at Karnak faces the sunset at the time of the summer solstice. A stone avenue stretches through the axis of the temple for five hundred yards, and throughout all the halls of the building nothing was allowed to obstruct the view through this avenue toward the point where the sun dropped below the horizon on the longest day of the year. Other temples elsewhere were oriented toward the same point. Still others appear to have been oriented with reference to stars. Ruins of old temples have been found and beside them a less ancient structure with an axis pointing in a somewhat different direction. Inasmuch as stars change their declinations about a degree in three hundred years, this circumstance of a changed axis in the new temple strongly supports the theory of stellar orientation. Many similar facts are given by Prof. Lockyer, and in connection with them he sets forth the astronomical basis of the Egyptian pantheon, describes the Egyptian calendar, and constructs, from the various monuments, inscriptions, and other available material, a chronicle of the succession of moon cult to sun cult, and of the mingling of these together and with various star cults, as successive waves of population inundated the valley of the Nile. The volume is copiously illustrated with views of temples and other monuments, figures of gods, diagrams, etc.

SEWAGE DISPOSAL IN THE UNITED STATES. By GEORGE W. RAFTER, M. Am. Soc. C. E., and M. N. BAKER, Ph. B. New York: D. Van Nostrand Co. Pp. 598. Price, $6.

THIS substantial volume embodies a comprehensive survey of the operations for the disposal of sewage that have been carried on in the United States. The conditions and needs governing sewage disposal in this country being somewhat different from those existing abroad, the authors believe that the information which they have gathered will be of peculiar benefit to American sanitary officials and engineers. The work is divided into two parts, the former of which is a discussion of principles, while the latter consists of descriptions of works. The practice of discharging sewage into fresh-water streams and lakes from which the water supplies of towns are taken has given rise to many of the most perplexing problems that sanitary engineers have had to deal with. Accordingly, the pollution of streams by sewage and manufacturers' waste and the self-purification of streams thus polluted are among the earliest topics treated in this work, their legal as well as their scientific aspects being duly considered. The authors regard as not proved the assertion that polluted streams are rendered fit for drinking by natural agen-

cies in the course of a few miles' flow. They see no objection to discharge into tide-waters or large lakes, and meet the argument as to waste of material by stating that the organic matter in sewage serves as food for low forms of animal life, which in turn sustain food fishes. The various modes of treating sewage—by chemical precipitation, broad irrigation, and intermittent filtration—are then described. Since rye grass, one of the species of useful plants that succeed best on sewage farms, does not cure easily, but may be readily preserved by ensilage, the silo beomes a valuable adjunct to the sewage works. In the portion of the volume devoted to descriptions of works, the establishments at more than twenty places are described with considerable detail and with figures, maps, and diagrams. There are also brief accounts of the use of sewage for irrigation at a number of places in the West. Various laws and codes of rules regulating the disposal of sewage in the United States and England are given in appendixes.

A HANDBOOK OF GOLD MILLING. By HENRY LOUIS. London and New York: Macmillan & Co. Pp. 504. Price, $3.25.

BUT few arts remain that have not been brought under the sway of science, with the result of securing improved products, a reduction of waste, lessened drudgery for man and beast, or an increased return for the same amount of effort. The separation of gold from the rock and gravel in which it occurs was carried on by wasteful empiric methods so long as rich deposits were available, but now that lower-grade ores must be largely depended upon, a disposition to work in the light of exact knowledge is becoming manifest. The present volume is designed to aid in the technical instruction of gold millers. It gives no space to the separating operations connected with hydraulic mining, the stamp mill being its only theme. After some preliminary chapters on the occurrence of gold, the properties of gold and mercury, and the formation of amalgams, the processes and appliances for the several steps of the modern milling process are taken up in order. Rock breakers, mortar boxes, stamps, frames, guides, and their various accessories are described and are illustrated in views and detailed drawings. The processes of amalgamation, concentration, cleaning-up, and the cleaning, retorting, and melting of the amalgam are then discussed and the appliances required for them are set forth. Some information is given with regard to the cost of milling, labor, power, sampling, and assaying of ore, etc., and several useful tables together with an essay on the cam curve are contained in an appendix.

THE INDUSTRIES OF RUSSIA. Prepared by the Department of Trade and Manufactures, Ministry of Finance, for the World's Columbian Exposition. Editor of the English translation, JOHN MARTIN CRAWFORD, U. S. Consul General to Russia. G. P. Putnam's Sons, New York, American Agents. Five volumes. Price, $6.

THE Russian Empire took an active part in the exhibition of 1893 at Chicago. Wishing to afford the American people a fuller idea of the industrial capabilities of Russia than the material exhibit of that country could convey, the Imperial Minister of Finance caused to be prepared this series of volumes which comprise sketches, by especially qualified writers, of the several chief industries of the empire. The first volume is devoted to manufactures and trade, and opens with a general view of this field by the distinguished chemist, Prof. D. I. Mendeléeff, who also contributes papers on the chemical industry and naphtha to this volume. Papers on the various textiles are furnished by N. P. Langovoy, professor in the St. Petersburg Technological Institute, and others on paper, leather, metals, glass, food products, tobacco, spirits, shipbuilding, etc., are contributed by other writers. Of a more general scope are the essays on the interior trade and fairs of Russia, the foreign trade, wages and working hours in factories, tariff systems, etc. The third volume, which is the largest of the five, containing over five hundred pages, is devoted to agriculture and forestry, the various features of these industries being treated by a large number of special writers. Mining and metallurgy are treated in a volume of a hundred pages by Mr. A. Keppen, mining engineer. The fifth volume is devoted to Siberia and the Great Siberian Railway, giving a description of the country and its resources, the history of its occupation by

Russia, and an account of the preliminary work on the railway. The writers of all parts of these volumes have a special acquaintance with their respective subjects through a connection with technical institutions or the Government service. Tables of statistics and many colored maps add to the value of the work.

ELEMENTARY METEOROLOGY. By WILLIAM MORRIS DAVIS. Boston: Ginn & Company. Pp. 355. Price, $2.70.

THIS treatise, which is the outcome of fifteen years of teaching and study in Harvard College may be used either as a text-book or for general reading. It opens with a consideration of the origin and uses of the atmosphere, with its extent and arrangement around the earth. As the winds arise from differences of temperature, the control of the temperature of the atmosphere by the sun is then discussed. The motions of the atmosphere and its varying quantities of moisture are next studied. After this we are led to the discussion of those more or less frequent disturbances which we place together under the name of storms. The closing chapters deal with the ordinary succession of atmospheric phenomena on which our local variations of weather depend, and the average conditions which, repeated year after year, we call climate. Some account is also given of the methods employed in predicting the weather. The text is illustrated with maps, diagrams, and cuts of apparatus.

APPEARANCE AND REALITY: A METAPHYSICAL ESSAY. By F. H. BRADLEY, M. A., LL. D., Fellow of Merton College, Oxford. London: Swan, Sonnenschein & Co. New York: Macmillan & Co. Pp. xxiv + 558. Price, $1.75.

A DECIDEDLY ingenious volume, and, to employ a schoolboy term, brimful of "criss-cross" reasonings. Though few names are mentioned, nearly all the great thinkers come under the author's knife. In fact, as the author intimates, to read the work intelligently, one must have read and widely. It is rather favorable than otherwise to allege, of almost every page within the covers, that the reader will doubtless, here and there, discover himself uttering two ejaculations, viz., How does the author know? and, Well reasoned for so ingenious a query! Indeed, at every step we encounter a forest of questions in a field of doubt. At the very opening, the critic is not only disarmed, but Prof. Bradley comes to his own rescue with his own sword, for he "would rather keep" his "natural place as a learner among learners." Hence, "if anything in these pages suggests a more dogmatic frame of mind" he "would ask the reader not hastily to adopt that suggestion. I offer him," he says, "a set of opinions and ideas in part certainly wrong, but where and how much I am unable to tell him. That is for him to find out if he cares to, and if he can." The chief aim of the book is to supply "a skeptical study of First Principles." So, the student, with this in mind, proceeds to ask how can there be, as alleged (preface), any "positive function of the universe," when "outside of spirit there is not and there can not be any reality" (closing lines, page 552); yet withal, "spirit" is nowhere in the book defined, while things around us that are generally accepted as real are (page 127) no "more than mere appearance." These passages detached from the text might constitute a partial injustice were they not the main makes-up of the author's labors. While paradoxes in philosophy are in the aggregate not desirable, they sometimes serve a useful end, and, on the like plane, perplexities in logic may have a place for those who care to pursue the narrow and thorny path to their hiding. One thing, though not stated, is clearly enough perceptible in a perusal of Appearance and Reality: the universe is to each one according to his faculties, and even the earthworm has its world. Instead of taking to the ocean to reach the author's distant shore, he might have landed us in a nutshell across some surer though narrower channel. The work contains twenty-seven chapters, is divided into two books, and constitutes one in Series No. 3 of the Library of Philosophy.

In a lecture on *The Status of the Mind Problem*, Mr. *Lester F. Ward*, of Washington, predicates the dependence of mind and body while carefully avoiding the predication of their identity. Concerning the "mystery of mind," he offers the simple explanation that "the phenomena of mind stand in the same relation to the brain and nervous system that all other phenomena

stand to the substances that produce them; in a word, that the mind is a property of the organized body." Mind is no more a mystery than matter, except that its phenomena being more complex, we possess as yet much less knowledge of them than we do of many of the simpler phenomena of Nature.

The *Report of the United States Commissioner of Fish and Fisheries* for 1889 to 1891 contains, besides the summary of the work of the commission and its different stations, reports by Richard Rathbun of the Inquiry respecting Food Fishes and the Fishing Grounds, and by Hugh M. Smith regarding the Methods and Statistics of the Fisheries; and, in the Appendices, reports, by Z. L. Tanner, on the Investigations of the Steamer Albatross; by C. T. Townsend, on the Oyster Resources and Oyster Fishery of the Pacific Coast of the United States; and by C. H. Stevenson, on the Coast Fisheries of Texas; with papers on the Sparoid Fishes of America and Europe, by D. S. Jordan and Bertt Fisher; Fish Entozoa from Yellowstone Park, by Edward Linton; and Ernst Haeckel's Plankton Studies on the Importance and Constitution of the Pelagic Fauna and Flora (translated by G. W. Field).

A pamphlet by Mr. *Alexis A. Julien*, entitled *Notes of Research on the New York Obelisk*, contains, under the significant title of *Misfortunes of an Obelisk*, a history of the obelisk in Central Park from the time it was quarried at Syene till it was brought and erected in its present position; together with a *Study of the New York Obelisk as a Decayed Bowlder*. The author regards the obelisk as liable to rapid decay in our damp and variable climate, and his chief object appears to be to discover the best means of arresting its disintegration. He approves of the paraffin treatment that has been applied to it, but believes, and seeks to demonstrate, that it was originally gilded; and that if again covered with gold it will be restored to its first estate and be most effectually protected against further deterioration.

From *Romeyn Hitchcock*, Chicago, Ill., we have of his contributions to the United States National Museum *The Ainos of Yezo, Japan* — one of the most satisfactory and valuable works on the subject that has appeared; *The Ancient Pit Dwellers of Yezo, Japan; Shinto, or the Mythology of the Japanese; The Ancient Burial Mounds of Japan;* and *Some Ancient Relics in Japan.*

The first paper, and the one occupying the most space, in the *Archivos do Museo Nacional do Rio de Janeiro* (Archives of the National Museum of Rio de Janeiro), is by Dr. Emilio Augusto Goldi, On a Disease of the Coffee Tree in the State of Rio de Janeiro, which is produced by a nematoid worm, *Meloidogne exigua*. Dr. Fritz Müller describes the metamorphoses of *Trichodactylus*, a fresh-water crustacean, and furnishes besides papers on *Janira exul*, an isopod crustacean of the State of Santa Cattarina, and two shrimps—*Atyoida potimirum* and *Palæmon potiuna;* and Dr. Hermann von Shering contributes a description and anatomy of *Peltella*.

The *Journal of Morphology*, under the editorial conduct of Prof. *C. O. Whitman* and Mr. *Edward Phelps Allis*, Jr., continues to furnish the best results of the most careful researches in the branch to which it is devoted. No. 2 of Vol. VIII (May, 1893) contains the second part of Prof. J. S. Kingley's study of The Embryology of Limulus; The Habits and Development of the Newt, by Edwin O. Jordan; The Formation of the Medullary Groove in the Elasmobranchs, by William A. Lucy; Biological Changes in the Spleen of the Frog, by Alice L. Gaule; Histogenesis of the Retina in Amblystoma and Necturus, by F. Mall; and Homology of the Centrosome, by S. Watasé. All these articles are suitably illustrated in the plates.

No. 2 of Vol. I of the *Contributions to the Botanical Laboratory of the University of Pennsylvania* is devoted to a Botanical and Economic Study of Maize, by John W. Harshberger. The botanical account, under which are included gross anatomy, histology, bibliography, synonyms, and name, is followed by a discussion of the origin of maize, with evidences afforded by meteorology, botany, archæology, ethnology, philology, and history; after which its geographical distribution, chemistry, agriculture, physiology, utility, and future are considered.

The paper of Mr. *William Trelease*, of the Missouri Botanic Garden, St. Louis, on *The Sugar Maples, with a Winter Synopsis of all North American Maples*, is devoted, first, to the identification and description of the varieties which are known in different parts of

the country as sugar maples; and, second, to a detailed botanical description of the winter appearance of the several species of maple; giving the characters of bark, color, etc., of twigs, buds, and other marks apparent in winter by which the species may be distinguished at that season. The leaves, seeding, and buds of several of the varieties are further illustrated in engravings.

The report of *The Peabody Museum of American Archæology and Ethnology* represents that during the absence of Curator Putnam as chief of the Department of Ethnology at the Chicago Exposition the work of the museum was continued without interruption. Much progress was made in the arrangement of collections in the new halls, one of which is devoted to the objects gathered by the several expeditions to Yucatan and Honduras during the past five years. The expedition of 1892–'93 was prematurely terminated on account of the death of its chief, Mr. Owens, and the placing of another expedition is delayed. A memoir on Indian Music, by Miss Fletcher, published as No. 5 of the museum papers, is the result of twelve years' study, and contains the words and music of nearly one hundred songs of war, friendship, love, and ceremonial, with a scientific study of the structure of Indian music. The museum's exhibit at Chicago was of the most satisfactory character.

The Chemical Publishing Company, Easton, Pa., are publishing in monthly numbers, to be of 48 pages each, *Principles and Practice of Agricultural Analysis*, by Dr. *H. W. Wiley*. The work will be issued in two volumes, of which the first, in ten numbers, comprising nearly five hundred pages, will contain a description of the origin of soil and fertilizers, and the method of their examination; and the second will be devoted to the best approved methods of analyzing agricultural products. An attempt will be made to condense all the material into twenty-four numbers; but if this can not be done, a third volume will be published. The price of the work will be 25 cents a number. Publication began in January, 1894.

Naturæ Novitates—Natural History News—is the name of a semimonthly publication giving a bibliographical list of current literature of all nations in natural history and the exact sciences, published by R. Friedlander & Son, Berlin, N. W., Carlstrasse, 11, at 25 cents a number. All titles entered are numbered consecutively from 1 up.

A *Laboratory Manual* of 90 pages, consisting of a course of experiments in organic chemistry, by *W. R Orndorff*, assistant Professor of Chemistry at Cornell University (D. C. Heath & Co., 40 cents), is arranged to accompany Remsen's Organic Chemistry. It contains a commendatory preface by Remsen. Each experiment is followed by a series of questions and a blank sheet for notes.

Under the simple title *Guide to the Study of Common Plants*, Prof. *Volney M. Spalding* has published a thoroughly practical manual of laboratory study in botany (Heath, 85 cents). The author supports fully and freely the modern doctrine that a knowledge of things should be gained through studying the things themselves rather than what some one has written about them. The book is adapted to classes in high schools and similar institutions. The pupils are assumed to have parts of plants before them at every lesson, and the exercises consist of directions for examining this material so as to learn what it has to teach. Seven chapters are given to the several principal parts of flowering plants, after which the chief botanical families represented among common plants are studied in succession. Full directions for study, lists of material, apparatus, and reference books are given, and there is some practical counsel for student and for teacher.

The plan of the recently issued *Treatise on Hydrostatics*, by Prof. *Alfred G. Greenhill*, of Woolwich (Macmillan, $1.90), is to develop the subject from the outset by means of illustrations of existing problems. In this way the author hopes that the student will acquire a real working knowledge of the subject, while at the same time the book will prove useful to the practical engineer. Particular attention has been given to the applications of the subject in naval architecture. With regard to details it may be mentioned that the condensed notation of units proposed by M. Hospitalier at the International Congress of Electricians of 1891 has been employed, and in the mathematical processes a free use has been made of the symbols and operations of the calculus. In support of the latter policy the author quotes the saying

that "it is easier to learn the differential calculus than to follow a demonstration which attempts to avoid its use." Pneumatics and hydraulics have been included as divisions of hydrostatics, and there is a chapter on the mechanical theory of heat.

Dr. *Daniel G. Brinton* has reprinted from the Proceedings of the American Philosophical Society his account of *Nagualism*—a mystic cult that flourished in Mexico and Central America in the times of conquest and colonization (David McKay, Philadelphia, $1). The nagualists were of various tribes and languages, united in a powerful secret organization; they exercised necromantic powers and held occult doctrines. They were animated by an intense hatred of the Spanish explorers, and their one purpose was the destruction of the invaders and the annihilation of the government and religion introduced by them.

A recent bulletin of the United States National Museum is *A Monograph of the Bats of North America*, by *Harrison Allen*, M. D., being designed to take the place of the author's monograph on the same subject issued thirty years ago. The new work is made larger than the old by the addition of species and by elaboration of the descriptions. Thirty-eight plates, showing anatomical details, accompany the text.

A sketch of travel in California, by Rev. Dr. *Charles A. Stoddard*, has been published under the title *Beyond the Rockies* (Scribners, $1.50). Dr. Stoddard describes the fruit orchards, the wonderful climate, the big trees, the Yosemite Valley, the old missions, San Francisco and other Californian cities, etc., in a chatty and entertaining style. Incidents of travel are also mingled with the descriptions, and there are accounts of the scenery and stopping places in Texas, New Mexico, Arizona, Utah, and Colorado, which were passed through either in going or coming. The volume is copiously illustrated with photo-engravings of the places described.

A new translation of *The Social Contract*, of *Jean Jacques Rousseau*, with an introduction and notes by Prof. *Edward L. Walter*, has been issued (Putnam, $1.25). Students of political science will find in this book "the most striking statement of a theory destined to mold profoundly the history of nations," and will discover within it, also, "the weapons which are first sharpened and polished, and then directed against the whole framework of the modern state." The introduction reviews the political circumstances in which the treatise appeared, and the notes give historical facts concerning the persons and events referred to in the text, or references to books from which full information may be obtained.

In *David T. Day's* report on the *Mineral Resources of the United States* for 1892, the ninth of the series, the statistical tables of previous years are carried forward. Instead of chapters, the book is divided by mineral topics, which are so arranged as to bring kindred subjects together. The work is the result of a census conducted by the principal experts on each subject.

The *Report of the Chief of the Weather Bureau for 1891–'92* is the first volume of the meteorological data published by the office as now constituted, and continues the series heretofore published by the War Department. The necessity of crowding two years' work into one report has compelled condensation by the omission of the detailed hourly and twice daily observations; but this omission is partly supplied on the daily weather maps. Tables of monthly and annual normal pressure, temperature, and precipitation are given. A description of the instrumental equipment of observing stations by Prof. C. F. Marvin, and a report by Prof. Cleveland Abbe on the instrumental corrections, methods of reduction, and the probable resulting accuracy of the observations and the means, add much to the value of the volume. *Mark W. Harrington*, chief of the bureau.

The Commissioner of Labor of the United States publishes a special report on *Compulsory Insurance in Germany*, which has been prepared at his request by Mr. *John Graham Brooks*, after residing in Germany and making a careful and broad study of the subject and all the circumstances surrounding. The author was commissioned to collect all the official information available with reference to the system, and to ascertain in all legitimate ways its real workings, its effect upon labor and the workingman, and its general tendencies. Neither approving nor condemning the system, Mr. Brooks has given the

reasoning for and against it, and its results, taking up the steps which led to its institution and showing the phases attending its beginning and the experience under it after it was established. The report shows that the system aims at securing all that has been aimed at under various systems of charity, and that its ethical side was most potent in securing its establishment. It also appears that the compulsory insurance laws were not, as has been supposed, the result of a sudden conviction of an emergency to be met, but came directly through evolutionary processes covering long periods of time.

Besides the regular accounts of proceedings and progress, and the Report of the Secretary, the *Annual Reports of the Board of Regents of the Smithsonian Institution* for 1891 and 1892 contain in the general appendixes brief accounts of scientific discoveries in particular directions; occasional reports of the investigations made by collaborators of the institution; memoirs of a general character or on special topics, both original and selected; and other papers, as space permitted, supposed to be of use or value to the correspondence of the institution. The attention of the Board of Regents was largely given, during the two years covered by these reports, to the establishment of an Astrophysical Observatory. An accession of $200,000 to the endowment of the institution has been obtained through the bequest of Mr. Thomas G. Hodgkins, of Setauket, Long Island.

A map and tables of the *Average Elevation of the United States*, published by *Henry Gannett* in connection with the United States Geological Survey, give, in the map, by gradations of color, the elevations, at intervals rising from five hundred to three thousand feet, of the country and mountains, from the few spots below sea level up to "above ten thousand feet"; and, in the tables, the number of square miles, in each State and in the whole Union, at each grade of level, and the mean elevations of the several States.

The report of *Barton W. Evermann* and *William C. Kendall* on *The Fishes of Texas and the Rio Grande Basin* (United States Fish Commission) is designed to complete the studies published in a report made in 1892 preliminary to establishing a fish-cultural station in Texas. It is intended to include all the species, both salt and fresh water, which have been reported from the region named, so far as the authors have been able to learn. Geographically the paper is made to include, besides the State of Texas, all those parts of Colorado, New Mexico, and Mexico that belong to the hydrographic basin of the Rio Grande. The geographical distribution of the fishes is prominently considered. The report is illustrated by forty plates.

The Living Method for Learning how to Think in German proceeds on the assumption that if one tries to speak German while thinking in English, his conversation will consist largely of pauses, in efforts to recall the German expressions and to arrange them idiomatically; and that the only way to speak German is remembering what Germans say under the same or similar circumstances; not that one should live in Germany, but that he should live in German. The process is to associate the foreign phrases we have learned so perfectly with our actions that they will mentally suggest each other. The book furnishes the phrases for usual acts; then, whenever we do any of the acts, we should say, or think — in German — what we are doing. From this we go on, expanding our knowledge and practice, and making and learning new combinations. (*Charles F. Kroeh*, author and publisher, Hoboken, N. J.)

The Mechanics of Hoisting Machinery (Macmillan & Co., $3.75) is a translation made by *Karl P. Dahlstrom* from Prof. Herrmann's revised edition of Weisbach's great work on Engineering Mechanics—a work of which several volumes, treating of special subjects, are already familiar through translations. The present volume, however, has never heretofore appeared in English, although its value is generally recognized. The edition is intended as a text-book for technical schools and a guide for practical engineers. Within its purview are included levers and jacks; tackle and differential blocks; windlasses, winches, and lifts; hydraulic hoists, accumulators, and pneumatic hoists; hoisting machinery for mines; cranes and shears; excavators and dredges; and pile drivers.

The Peerless Cook Book, embracing more than one thousand recipes and practical suggestions to housekeepers, by Mrs. *T. J.*

Kirkpatrick, appears to be well adapted to the needs of working housekeepers. The recipes are plain, direct, and comprehensible, and for practicable dishes which may be in common use in the most modest households. They are also abundant in variety. Much pains is taken in the arrangement, and the articles are placed where they would come in a regular course dinner. Many of the recipes have been gathered from practical housekeepers; and of these not a few are original with the ladies and have never before been in print. The practical suggestions are excellent. (Mast, Crowell, and Kirkpatrick, Springfield, Ohio. Price, 50 cents).

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POPULAR MISCELLANY.

Social Factors of Crime.—Discussing the subject of criminology in one of the circulars of the Bureau of Education, Mr. Arthur MacDonald speaks of crime as seeming to be, to a certain extent, Nature's experiment on humanity. If a nerve of a normal organism is cut, the organs in which irregularities are produced are those which the nerve controls. In this way the office of a nerve in the normal state may be discovered. The criminal might be spoken of as the severed nerve of society, and the study of him as a practical way (though indirect) of studying normal man. The relation of criminology to society and to sociological questions is already intimate, and may in the future become closer. Just what crime is at present depends more upon time, location, race, country, nationality, and even the state in which one resides. But notwithstanding the extreme relativity of the idea of crime, there are some things in our social life that are questionable. A young girl of independence, but near poverty, tries to earn her own living at three dollars a week, and if, having natural desires for a few comforts and some taste for her personal appearance, she finally, through pressure, oversteps the bound, society, which permits this condition of things, immediately ostracises her. It borders on criminality that a widow works fifteen hours a day in a room in which she lives, making trousers at ten cents a pair, out of which she and her family must live, until they gradually run down toward death from want of sufficient nutrition, fresh air, and any comfort. It is criminally questionable to leave stoves in cars so that, if the passenger is not seriously injured but only hedged in, he will have the additional chance of burning to death. It has been a general truth, and in some cases is one still, that a certain number of persons must perish by fire before private individuals will furnish fire escapes to protect their own patrons. It is a fact that more than five thousand people are killed yearly in the United States at railroad grade crossings, most of whose lives could have been saved had the road or the railroad passed either one over the other. The excuse of the expense is pleaded for the lack of the improvements; or, practically, it is admitted that the extra money required to introduce them is of more consequence than the five thousand human lives. And yet, strange as it may seem, if a brutal murderer is to lose his life and there is the least doubt that the crime was premeditated, a large part of the community is often aroused into moral excitement or indignation, while the murdered innocent railroad passenger excites little more than a murmur. There is no subject on which the public conscience is more tender than the treatment of the criminal. Psychologically, the explanation of this is simple, for the public have been educated gradually to feel the suffering and misfortunes of the criminal—things it is easier to realize, since the thought is confined generally to one personality at a time. If the public could all be eyewitnesses to a few of our most brutal railroad accidents, the consciousness gained might be developed into conscientiousness in the division of their sympathies. The feeling spoken of is a sincere though sometimes morbid expression of unselfish humanitarianism.

The Arctic Sea.—In his address before the British Association on the Polar Basin, Mr. Henry Seebohm described the Arctic Sea, which lies at the bottom of the polar basin, as fringed with a belt of bare country, sometimes steep and rocky, descending in more or less abrupt cliffs and piles of precipices to the sea, but more often sloping gently down in mud banks and sand hills. These latter represent the accumulated spoils of countless ages of annual floods, which tear up the banks of the rivers and deposit shoals of detritus at their mouths, compelling them to make deltas in their efforts to force a passage to the sea. In Norway this belt of bare country is called the Fjeld, in Russia it

is known as the Tundra, and in America its technical name is the Barren Grounds. In the language of science it is the country beyond the limit of forest growth. In exposed situations, especially in the higher latitudes, the tundra does really merit its American name of barren ground, being little else than gravel beds interspersed with bare patches of peat or clay, and with scarcely a rush or a sedge to break the monotony. In Siberia, at least, this is very exceptional. By far the greater part of the tundra, both east and west of the Ural Mountains, is a gently undulating plain, full of lakes, rivers, swamps, and bogs. The lakes are diversified with patches of green water plants, among which ducks and swans float and dive; the little rivers flow between banks of rush and sedge; the swamps are masses of tall rushes and sedges of various species, where phalaropes and ruffs breed, and the bogs are brilliant with the white, fluffy seeds of the cotton grass. The groundwork of all this variegated scenery is more beautiful and varied still—lichens and moss of almost every conceivable color, from the cream-colored reindeer moss to the scarlet-cupped trumpet moss, interspersed with a brilliant Alpine flora, gentians, anemones, saxifrages, and hundreds of plants, each a picture in itself; the tall aconites, both the blue and yellow species; the beautiful cloudberry, with its gay white blossom and amber fruit; the fragrant *Ledum palustre*, and the delicate pink *Andromeda polifolia*. In the sheltered valleys and deep watercourses a few stunted birches, and sometimes large patches of willow scrub, survive the long, severe winter, and serve as cover for willow grouse or ptarmigan. The Lapland bunting and red-throated pipit are everywhere to be seen, and certain favored places are the breeding grounds of snipe, plover, and sandpipers of many species. So far from meriting the name of barren ground, the tundra is for the most part a veritable paradise in summer. But it has one almost fatal drawback—it swarms with millions of mosquitoes. The tundra melts away insensibly into the forest, but isolated trees are rare, and in Siberia there is an absence of young wood on the confines of the tundra. The limit of forest growth appears to be retiring southward, if we may judge from the number of dead and dying stumps; but this may be a temporary or local variation caused by exceptionally severe winters.

Cayuga Lake as a Rock Basin.—In a paper entitled Lake Cayuga as a Rock Basin, Ralph S. Tarr, after describing the topography of the region and giving a summary of the opinions previously held, attempts to prove that Cayuga, and presumably other of the lakes called Finger Lakes, is situated in a rock basin, with a maximum depth of approximately four hundred and thirty-five feet. The nature of the proof is that the preglacial tributaries to this valley are found to be rock-incased, and that their lowest points are above the present lake surface. The paper presents also a brief discussion of the reason why a rock basin may be supposed to have been constructed with comparative ease in this region, and a rhythm of glacial erosion and deposition is suggested. The course of the preglacial Cayuga River is found to be northward, probably tributary to a river which drained at least one of the Great Lakes—Ontario. As the tributaries of Cayuga River prove the rock-basin origin of Cayuga, so also the Cayuga River tributary of the Ontario stream indicates that Lake Ontario is likewise a rock basin.

The Expert Witness.—As one of the embarrassing features in the situation of the "scientific expert" witness, Prof. Charles F. Himes mentions that he is legally a witness, an ordinary witness, but practically endowed with extraordinary functions and loaded with extraordinary responsibilities—sometimes, perhaps, with extraordinary and even absurd expectations. As a witness he is under the same liabilities, rules, and restrictions as other witnesses, yet, by the circumstances under which he is called, he "exhibits the character of a very willing witness, of a well-paid witness, combined with a great deal of the advocate. Now, he can not be held responsible for this position, but the system of jurisprudence, which not simply permits it, which has not simply taken him but has forced him in, and which, apparently cognizant of all, seems only able to originate complaints rather than to provide a different character for him; for there seems, indeed, in many of the adverse criti-

cisms of experts, to be only a confession of weakness rather than a disposition earnestly to consider the whole question with a view to the radical remedy of the evils. The human nature of the judge is recognized and provided against. . . . The jury is selected so as to be free from bias, and is protected as well. Other witnesses are not expected to take the part the scientific expert is almost compelled to take. In fact, if deliberately planned, there could hardly be a network of conditions devised calculated to produce so many of the evils of scientific expert testimony complained of or to cloud this testimony of highest intrinsic value, having the highest degree of certainty, and in a field altogether its own." These witnesses are sometimes supposed to be selected on account of their ability to express a favorable opinion, when they are flippantly styled "adroit advocates of the theory of the party calling them"; but in how many cases, Prof. Himes asks, "does favorable opinion—or bias, if you please—precede the call of an expert rather than depend upon the call?" And the still more pertinent question, "How many experts are not in the particular case because their opinions are not wanted by the party who consulted them?"

Death Valley, California.—The principal features of popular interest in Death Valley, California, as described in Prof. Harrington's Notes on its Climate and Meteorology, are its excessive heat and dryness. The temperature rises occasionally in the shade to 122°, rarely falls at any time in the hot months below 70°, and averages 94°. It is not only hot in the summer, but consistently hot, and the heat is increased by occasional hot blasts from the desert to the south. The air is not stagnant, but in unusually active motion. Gales of a few hours' duration are very common, and sometimes produce sand whirls and sand storms. Rains may fall frequently in the mountains and occasionally in the valley. Clouds are by no means lacking, and water can probably always be found in the soil at the depth of a few feet, yet the heat and wind together keep the surface very dry and the relative humidity low. Animal and plant forms are comparatively few, and the former are usually nocturnal to avoid the heat. Both heat and aridity are increased by the character of the valley. It is narrow and deep, apparently the bed of an old sea, inclosed by high and dry mountains. The white and shifting sands become much heated under the noonday sun; the rest of the surface is in part salt and alkali, in part probably wash from the mountains, and in part a loose, spongy earth, over which it is difficult to move. With the exception of a few springs, the water is bitter and unwholesome. The meteorological features of interest lie, for the most part, in those modifications of diurnal changes which are due to the topography. The range of temperature is unusually great. The hourly progress of the wind shows enormous changes in speed, in direction, and in temperature. The diurnal change in the barometer is the most characteristic of the form found in continental valleys. It is of the purest single maximum type and has the largest amplitude known. With these features go sharp thunderstorms, limited to certain hours of the day, and daily gales and hot blasts. It is also noteworthy that the absolute humidity here is fairly constant, and is that belonging to that part of the world. The air in the valley is part of the general aërial ocean, and this shows no sharp contrasts in its moisture contents, except when wind prevails across a mountain ridge. Here the prevailing winds are up and down the valley, and its relative aridity is due to its higher temperature. The winter climate is believed to be cool and salubrious, with an inch or two of rain.

The Vacuum Jacket and Liquid Oxygen.—Prof. Dewar protects his liquefied gases, in order to keep them in that state, from the heat of convection, by inclosing them in a vacuum jacket; and from the heat of radiation by silvering the surface of the containing vessel. He is thus able to keep liquid air for thirty or forty hours. The vacuum used contains a little mercury vapor, which, though present in very minute quantities, can be condensed into a bright mirror by cooling the outside surface of the vessel with liquid air. Among the experiments made in one of Prof. Dewar's lectures to illustrate the properties of liquid oxygen, alcohol, which freezes at −120°, solidified when dropped into it, and in that state would not take fire. So-

dium burns with intense brilliancy in gaseous oxygen, but in liquid oxygen would not burn at all, the very low temperature (−180°) hindering chemical action. Liquid oxygen has an electrical resistance five or six times greater than that of the gas, which itself is strongly magnetic. Put under the poles of an electro-magnet, the liquid leaped up to them when the current was passed, and a little piece of cotton wool saturated with it was strongly attracted. Ordinary air from the room was liquefied in the presence of the audience. A small tube of liquid oxygen, placed in a vessel of air, was put under the air pump, and in a short time liquid air began to condense on its surface. Although the nitrogen and oxygen of the atmosphere are liquefied simultaneously, yet nitrogen, being the more volatile, boils off first, and leaves liquid oxygen behind. This can be proved by holding a glowing taper over a vessel of liquid air; it does not burst into flame until about four fifths of the contents have evaporated. Liquid air is magnetic, but more feebly so than liquid oxygen. It is also blue, and the absorption bands in its spectrum are less dark.

Bohemian Graphite.—Natural graphite occurs usually in masses and veins in the oldest rocks, like granite, gneiss, mica schist, and porphyry. At Schwarzbach, in Bohemia, it is found in irregular masses in the gneiss, apparently brought there after the formation of the rock, and having been substituted for the mica, of which it in some places takes the foliated texture. Schwarzbach is situated on a grassy plain among the wild mountains of southern Bohemia, in the district of Kruman. The mines and surrounding country belong to the immense domains of the Prince of Schwarzenberg. The mines employ eight hundred workmen, and produce from six thousand to ten thousand tons a year. The graphite is mined in shafts sunk one hundred metres or more beneath the surface of the ground. Being impregnated with water, it is easily broken into small blocks by the pick. It is sorted by the miner into first and second choice—*prima* and *raffinade*. These piles are again sorted, a different process being observed with either kind. The *prima*, which is designed for pencil-making, is sorted by hand, and all impurities and hard particles are removed from it. The *raffinade* is passed under millstones where a current of water passing carries off all the richest parts, and, giving up the sand and pyrites in a series of pans provided for them, carries the purified graphite into another series of pans. If pyrite is present in considerable proportions, it is burned out by passing the matter in gratings over flame.

The Waganda.—Describing Uganda in the British Association, Captain Williams said that whatever the merits of the country, the people were worth keeping, for they were a wonderful race. The missionaries had done great good, notwithstanding the conflict of religions. The men were fine, well built, and athletic, and the women were active and intelligent. They were not universally black—indeed, in Central Africa there was a considerable variety of shades. They had a strange theory of transmigration of souls, which prevented the people from utilizing the food supply that lay before them. The people were simply dressed; the women were not allowed to wear white cloth, while the men wore white if they could get it. They wore "bark cloth," which was stretched out on pegs to the right length. The Waganda were polygamists, each man having seven wives. The women were very happy, and did the hoeing and other agricultural work, while the men built the houses and carried the food. A man as a rule bought his wives. In one case he met a man who had bought a wife for four cows. He had paid two of the cows and then the lady was eaten by a leopard. He thought it was very hard lines that he should be compelled to pay the remaining cows. The houses were, as a rule, mere slight, temporary structures, but the house in which the late King Mtesa was buried was a wonderful structure with twenty feet or more of thickness of thatch. The churches —both Catholic and Protestant—were extremely fine, but the former had unfortunately been burned. The cruelties of the people had been much exaggerated, and were not comparable to the atrocities which were once committed. In former days a king had all the people killed who passed along a certain road from morning to night, and a man's life was almost worthless. The

love of music—especially the drum and the pipe and a sort of rude violin—was characteristic of the people. There was abundance of big game and the Waganda were capital hunters, and their method of hunting was quaint and original in the extreme. A huge crowd, armed with stout sticks, beat down the high grass level and tracked the leopard or lion to his lair, and, getting him inclosed within a space equal to a good-sized room, literally beat the beast to death, and it rarely happened that anybody was much hurt.

The Gothenburg System.—In summarizing his conclusions as to the advantages and disadvantages of the Gothenburg or company monopoly system of liquor traffic in operation in Sweden and Norway, Dr. E. R. L. Gould insists that the system was not originated with the idea of stopping the consumption of liquors, but to combat drunkenness and reduce the evils consequent upon inordinate indulgence in alcoholic drinks. It is founded, too, upon the principle that, since, taking human nature and practices as we find them, it is impossible immediately to eradicate the evil completely, it is better to regulate it through the higher rather than the lower elements of the community. Its strength lies along the line of preventive rather than of reformatory elements. Among the advantages named is, first, the complete divorcing of the liquor traffic from politics. Further, the company monopoly has been so administered that a general reduction of the number of licenses has been brought about everywhere, and, consequently, a lessening of the temptation to drink. "It would be a very strange condition of affairs indeed, in any matter of this kind, if, when the element of private gain was entirely eliminated, a resulting improvement did not take place." A series of effective checks is imposed against a breach of trust, supposing there may exist an inclination to commit it. The companies have, in some measure, gone beyond the legal requirements in the line of general interest, particularly in raising the age of minority from fifteen, where the law puts it, to eighteen, as regards selling drink to young persons, and also in insisting immediately on cash payments. They have gradually raised the price of drinks and reduced their strength. In Norway the saloons are closed on Sundays and at those times of day when the workingman is most tempted to drink. All men employed are paid fair fixed salaries, and there is no temptation to push sales. All taxes are paid under the company system without shuffling. The cause of temperance has been assisted financially and otherwise. The profits on sales of drink are expended for the relief of society. No community which has tried the system has afterward abandoned it. The measure is supported by the temperance party, though many of them would prefer prohibition. The disadvantages are laid mostly to defects in existing law, rather than to faults inherent in the system itself. The monopoly does not extend far enough, but should cover fermented drinks; the limit for retail sales is not fixed high enough; the sale of liquors is often connected with general business, from which it should be separated; a monopoly of production by the state does not exist; the question of profits is still too conspicuous; and, from the temperance view of the case, it is feared that the upper classes of society do not wish to go further than the Gothenburg system.

Volcanic Rocks in Eastern North America.—Mr. George H. Williams has insisted on the presence, in the oldest geological formations, of igneous rocks, disguised, perhaps, under a foliated structure, and has dwelt upon the methods by which their origin may be established. The object of a paper by him on The Distribution of Ancient Volcanic Rocks along the Eastern Border of North America is to show that igneous, and volcanic rocks as well, are widely distributed through the crystalline belt of eastern North America, and to direct attention to them as offering a new and promising field for work in crystalline geology. His review of the field leads him to the conclusion that this class of material is abundant. It has been identified from Newfoundland to Georgia. For many areas the evidence of surface or volcanic origin is conclusive, while in many others it is as yet only probable. The areas of these ancient volcanic rocks now known fall roughly in two parallel belts; of these, the eastern embraces the exposures of Newfoundland, Cape Breton, Nova Scotia, the

Bay of Fundy, coast of Maine, Boston basin, and the central Carolinas; while the western belt crosses the Eastern Townships and follows the Blue Ridge through southern Pennsylvania, Maryland, Virginia, and North Carolina, to Georgia. Further and fuller studies of the subject are desired by the author, who remarks that the identification of truly volcanic rocks in highly or partly crystalline terrains possesses far more than a petrographical significance, since, by fixing what was the surface at the time of their formation, they furnish a certain datum for tracing out the sequence of later geographic changes and geological development.

A "Copper Age."—An account of the discoveries made at Tel-el-Heyi, the site of the ancient city of Lachish, in Palestine, gave rise, in the British Association, to a discussion concerning a probable copper age. The very high mound contains the ruins of several towns, built each (except the lowest) on the ruined remains of its predecessor The uppermost was an Israelitish town, and was very probably the remains of the Lachish which was besieged and destroyed by Sennacherib in the time of Hezekiah. Throughout the mound, from the bottom to the top, were found flint and metallic implements. Among them was a thick chisel made of copper, which had been hardened by mixture with red oxide of copper, from which it received a red appearance. Toward the top of the mound were bronze arrowheads, which probably dated back to between 1400 and 1500 years B. C. In the ascent of the mound a change was observed from copper to bronze and from bronze to iron, which was very common in the Israelitish town. Lead was found in the form of a thick wire, very pure. A silver bangle contained ninety per cent of silver, considerable copper, and an appreciable quantity of gold. Sir John Evans spoke of the evidences of a copper age preceding a bronze age, seen in North America, Ireland, Hungary, and other countries. Dr. Hildebrand said that several implements of pure copper had been found in Sweden. Prof. Boyd Dawkins thought the evidence from North America showed that the copper age was practically a side of the neolithic age. Prof. A. H. Sayce spoke of the absence of words for tin in the Egyptian and Assyrian languages, although the metal was known in Egypt as far back as the eighteenth dynasty, and although there are words in both languages for gold, silver, iron, copper, bronze, lead, and possibly metallic antimony. The word for iron in Egyptian meant metal from heaven, and in Assyrian, heavenly metal. This would indicate that their iron was meteoric.

Feats of Diving Birds.—Naval architects are credited with saying that the highest speed in navigation could be obtained by submarine boats. The principle is illustrated in the diving birds, which are capable of shooting through the water with amazing velocity. While these birds live by catching fish in deep water far below the surface, they present many differences in outer appearance. In the collection at the London Zoölogical Gardens are black-footed penguins, guillemots, "darters," a puffin, and a cormorant. The penguin can not fly in the air, can not walk, but hops as if its feet were tied together; and can not swim; and can only with any grace fly under water. When the keeper of their quarters appears to feed the birds, they each behave in their characteristic way. The fish thrown into the water, the penguins instantly plunge beneath, when an astonishing change takes place, thus described by a writer in the Spectator: "The slow, ungainly bird is transformed into a swift and beautiful creature, beaded with globules of quicksilver, where the air clings to the close feathers, and *flying* through the clear and waveless depths with arrowy speed and powers of turning far greater than in any known form of aërial flight. The rapid and steady strokes of the wings are exactly similar to those of the air birds, while the feet float straight out, level with its body, unused for propulsion, or even as rudders, and as little needed in its progress as those of a wild duck when on the wing. The twists and turns necessary to follow the active little fish are made wholly by the strokes of one wing and the cessation of movement in the other; and the fish are chased, caught, and swallowed without the slightest relaxation of speed, in a submarine flight which is quite as rapid as that of most birds which take their prey in midair." The head and shoulders may be

brought above the surface for a second, and then disappear; but any attempt to remain on the surface leads to ludicrous splashing and confusion, for the submarine bird can not float. The movements of the cormorant are quite different. It does not plunge headlong, but "launches itself on the surface, and then 'ducks' like a grebe. Its wings are not used as propellers, but trail unresistingly level with its body, and the speed at which it courses through the water is wholly due to the swimming powers of its large and ugly webbed feet. These are set quite at the end of the body, and work incessantly like a treadle, or the floats of a stern-wheel steamer. Yet the conditions of submarine motion are so favorable that the speed of the bird below the surface is three or four times greater than that gained by equally rapid movements of the feet when it has risen and is swimming on the top." The "darters"—divers of the African and American lakes, compared to the survival of some ancient lizard—dive and swim much like the cormorant, except that the bird keeps its neck drawn back in the form of a flattened S when in pursuit of the fish. "Once within striking distance, the sharp bill is shot out as if from a catapult, and the fish is spiked through and carried to the surface. This ascent is made after each single capture. Sometimes the bird has great difficulty in disentangling the pierced fish from the spearlike beak, and its companion adroitly relieves it of the struggling victim and swallows the prize."

An Ominous Forecast.—A dismal future is foreseen by M. Leroy Beaulieu, with two new and exhaustive processes going on in Europe, and, we might add, demanded by large classes in America. They are the rapid increase of state and communal expenditure, which in France, Germany, Italy, and Great Britain is augmenting by leaps and bounds, mainly for unproductive outlay on defense; and the other is the still more rapid increase of demands for grants-in-aid to institutions intended to benefit the poorer classes. More education, more guarantees, more "civilization" of all kinds—there is no end to the proposals. Every European state except Austria-Hungary has already a large deficit; besides which the communal expenditure is advancing incessantly in France, and in a less degree in Germany, while in Italy it is menacing the foundations of society. It is impossible that the twofold expenditure, on the means of killing and on the means of philanthropy, should go on without new taxation, and every tax diminishes the fund available for the payment of labor. No prospect is seen of these two depleting processes coming speedily to an end. Formerly they were checked by the rage of the taxpaying classes; but universal suffrage disregards that, and may go on taxing until its mood changes, or its own sources of supply begin visibly to fail. The demands partly urged by actual necessities, and otherwise being in the line of modern philanthropy, "which desires improvement in everything except manly independence," and further promoted by the fact that reasonable wants increase more rapidly than the means of satisfying them, are likely to go on advancing. In view of these circumstances, men of M. Leroy Beaulieu's school think that a time of grave economic distress, producing great social and political changes, is at hand for western Europe.

NOTES.

THE plague reported as prevailing in China is described by a correspondent of the British Medical Journal as presenting all the symptoms of the true bubonic pest which devastated Europe in the middle ages. Although extinct in Europe, this pest has never ceased to prevail in China from time to time, and has also spread from there to Persia and Asiatic Russia. The present outbreak is characterized by intense symptoms corresponding to those of typhus, and by the bubonic boils characteristic of the disease. Europeans are not affected by it, except the soldiers who come directly in contact with it in disinfecting work. It is extremely contagious from person to person, but the danger from aërial infection is slight.

IN the "Crump Burial Cave," Blount County, Ala., which was discovered in 1840, were several coffins of black and white walnut, "dug out" of logs, twelve or fifteen human skulls, and other human bones scattered about, masses of galena, grooved like the aboriginal stone axes or mauls, as if for use as war clubs, and other more usual implements. Near this cave Mr. Frank Burns has since found an Indian ladder that had been used to climb up to a "rock house," a large, roomy, dry place under overhanging

cliffs of stone, which was also probably employed for burial purposes. The ladder was a trunk of a cedar tree, having seven or eight steps, eighteen or nineteen inches apart, made by cutting a scarf into the tree. There are many such houses, Mr. Burns says, in the coal measures, and they were used by the aborigines as dwelling or burial places.

A BLUE mineral discovered near Silver City, New Mexico, and supposed to be ultramarine, occurs in irregular veins and streaks in the lime carrying the silver ore which is mined at Chloride Flat. The specimens procured by Mr. G. P. Merrill for the United States Museum exhibit the earthy blue substance which on casual inspection resembles ultramarine, associated with calcite and other substances; the analyses show, according to Mr. R. L. Packard, a chemical resemblance to talc, although the physical properties of the two minerals are different.

A COMPANY engaged in the construction of an electric railway on the Jungfrau proposes to devote twenty thousand dollars to the erection of a geophysical observatory at an altitude of about fifteen thousand feet, and to apply one thousand dollars a year for its maintenance.

THE Jakuns, or aboriginals, of Johore (Malacca) live in small communities on the banks of jungle streams, subsisting miserably on fruits, tapioca, roots, and small fish and reptiles. They seldom remain long in the same spot, but wander from place to place, living under scanty leaf shelters built on rickety poles at a considerable height from the ground. It is not uncommon to find a dozen men, women, and children, in company with a tame monkey or two, a few dogs and cats, innumerable fowls, and perhaps a tame hornbill, living in perfect harmony under the same miserable shelter. These aborigines are all very expert fishermen, using chiefly the three-pronged spear.

THE National Home Reading Union of England has for four years followed the practice of taking its students every summer into the fields, to the places which best illustrate the subjects on which they are at work. Thus, this year, while the general meetings were held at Buxton, special meetings were held at Salisbury, for the study of the monuments, abundant in the district, illustrating the archæology, art, and history of early England—"from Stonehenge to Salisbury Cathedral." Special excursions were given for botany, geology, etc., and conferences on social and educational subjects.

DR. D. L. W. Robinson, President of the South Dakota State Board of Health, is convinced from experience in practice in that region of great climatic variation and pressure that a close relationship exists between weather changes and health and disease. Yet he fails to identify this relationship specifically with either barometric changes or low temperature, and suggests that it may be connected with electrical conditions as the principal factor.

ACCORDING to the Bulletin of the American Geographical Society, the recent study of the observations on mountain summits in the neighborhood of Mount St. Elias shows that Mount Logan is the loftiest peak in North America, its height being 19,500 feet—1,200 feet greater than that of Orizaba, and 1,500 feet more than that of Mount St. Elias.

OBITUARY NOTES.

THE death is announced at Geneva, Switzerland, of the eminent chemist, J. C. de Marignac, formerly professor in the University of Geneva. He retired from his professorship in 1878, but continued his studies in a laboratory, which he fitted up at home, till the end of his life. He was well known for his researches on ozone and on chlorine, silver, potassium, sulphuric acid, and other substances in the domain of mineral chemistry. He was a correspondent of the Institute of France, and received the gold medal of the Royal Society in 1886. He was modest to excess and led a retired life of labor, the fruits of which made his name known throughout the world.

THE death is announced of Prof. Adolph Leipner, Professor of Botany in University College, Bristol, England. He had been honorary secretary from its beginning in 1862, and was at the time of his death President of the Bristol Naturalists' Society.

PROF. AUGUST KUNDT, the eminent physicist, died May 21st at his country place near Lubeck, fifty-four years of age. He was born at Schwerin in 1839 and was graduated from the University of Berlin in 1864, presenting as his thesis an investigation on the depolarization of light. He became a privatdocent in the University of Berlin in 1867, and was afterward a professor in the Polytechnic Institution at Zurich, at Würzburg, in the University of Strasburg, in the organization of which he had an important part, and in the Berlin Physical Institute, where he was also director. His first investigations were in acoustics and were gradually extended to embrace a large range of subjects. Perhaps the most important of them were in optics and magneto-optics.

M. A. DERBÈS, one of the pioneers in the study of the life history of the algæ, has recently died in Marseilles, France. In conjunction with M. Solier he was the author of a work on Zoöspores of the Algæ and the Antharides of the Cryptogams, published in 1847, which was rich with new facts and formed the basis of all later observations on the same subject.